THE ORTHOGONAL

SYSTEM OF HAND-RAILING,

WITH

PRACTICAL ILLUSTRATIONS

OF THE

CONSTRUCTION OF STAIRS.

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PREFACE.

THE application of the section of a cylinder to the construction of the face-moulds of a hand-rail originated with the late Mr. P. NICHOLSON. It has, however, been found, in applying the rules laid down by the above writer to practice, that the face-moulds given by them were incorrect, that, in fact, the lines given as the butt-joint lines of the face-mould were entirely out of their proper place, and, consequently, led to the most erroneous results. It has also been found that the face-mould itself given by the cylindrical section is not of the most advantageous form, in point of economy, that may be employed in cutting the wreath out of the plank. The construction of the Hand-rail upon the principles of the Orthogonal System is more economical, and the face-mould is more easily applied to the plank. The principles of this system were laid by the author before the Society of Arts, for-which he was awarded the large Silver Medal. In the following pages, the problems necessary in the construction of hand-rails upon the principles of the Orthogonal System will be found to be solved in the simplest possible manner; for instance, the problem for determining the direction of the ordinates in the construction of the face-moulds is solved with four lines, which

is less than one-third of the number employed by Nicholson for the same purpose. The construction of the butt-joint lines of the hand-rail upon strict geometrical principles, the determination of the scroll from the logarithmical spiral, and several other new and interesting details, originating with the writer, will be found distributed throughout the work.

In the department devoted to the construction of Stairs, the author must confess that little is added that was not previously known. It was only for the sake of obviating the necessity of referring the reader to other, and more expensive, works that this part was introduced. The main object of the writer being to give a system of hand-railing, simple, economical, and upon correct principles; if, in the introduction of the Orthogonal System he has succeeded, his object is fully accomplished.

J. JEAYS.

May, 1850.

PRACTICAL ILLUSTRATIONS

OF

THE CONSTRUCTION OF STAIRS.

PART I.

ARTICLE 1. IN treating of the construction of stairs, it is intended to give the different processes as they occur in practice. The proportion of the height of a step to its breadth, and the absolute dimensions of the step, are matters of the highest importance in the formation of stairs, a general rule will, therefore, be given to determine them.

GENERAL THEOREM FOR DETERMINING THE HEIGHT OR BREADTH OF A STEP.

2. The steps of stairs vary in their breadth from eight to fifteen or sixteen inches, and in their height from four to eight or nine inches, the most commodious step appears to be one of ten or eleven inches in breadth, with a height of five or six inches, the height of the step diminishing in an inverse ratio as its breadth increases.

Let R represent the riser, and T the tread of a step, the proportions of which have been determined, and r and t the riser and tread of a required step; by having the two values R and T, we are enabled to find a fourth, proportional to another given value r or t. That is, if we have the height r of the riser given, we are enabled to find the breadth t of the tread, or if we have the breadth t of

the tread given, we are enabled to find the height r of the riser, by the following proportions :—

$$r : R :: T : t;$$
$$t : T :: R : r.$$

The value of the fourth or last quantity, is found by multiplying the second and third quantities together, and dividing their product by the first, as expressed in the following formulæ :—

$$\frac{R\,T}{r} \quad . \quad . \quad (1.) \quad \text{or} \quad \frac{T\,R}{t} \quad . \quad . \quad (2.)$$

accordingly, as the riser or tread of the required step is given.

2. Taking, for example, a step eleven inches in breadth and six in height as the proportion to find the breadth of another step, the given height of which is seven inches. Substituting the above numerical values in formula 1, we have r equal to seven inches, R the height of the given step equal to six inches, and T the breadth of the given step equal to eleven inches; multiplying together the two last numbers, eleven and six, we have 66, which being divided by seven gives 9.4 nearly, or nine inches and four-tenths for the breadth of the step.

Again, let it be required to ascertain the breadth of a step, the height of which is four inches; substituting 4 for r in formula 1, we have 4) 66 (16.5, or sixteen and a half inches for the breadth of a step, having a height of four inches.

3. Nearly the same procedure as the above, is adopted in finding the height of a step when the breadth is given; in examining formulæ 1 and 2, it will be seen that the product of the same quantities is made use of as the dividend in both cases, the only variation is in the divisor,

which in one case is the height of the riser, and in the other, the breadth of the tread; in other respects the two formulæ are the same.

EXAMPLE:—Let the breadth of a step be 13 inches, required the height; we have 13) 66 (5.08, or five inches nearly for the height of the step.

It may be here remarked, that there is a limit to the height and breadth of a step which cannot, with propriety, be passed; no step ought to be inconveniently high, nor unnecessarily wide, extremes either way will be productive of an unpleasing effect. The absolute dimensions of steps must depend, in some degree, upon the purpose they are intended to fulfil. Steps that would answer very well for the stairs of small houses, would be ill adapted for houses of a larger class, and totally unfit for public buildings in general. Workmen need not by any means be confined to the dimensions of steps above given, it will, however, be found convenient to fix upon some number as a constant, for a dividend, and the number 66 is, perhaps sufficiently exact for all ordinary purposes.

THE STORY-ROD.

4. Before proceeding to lay down the plans of stairs, it is necessary to determine upon the number of steps to be employed in the story; this is done by what is termed dividing the story-rod:—Take a straight rod of wood, sufficiently long to reach from the floor of one story to the floor of another, place one end of it upon the floor of the lower story, and holding it in a perpendicular direction, mark upon it the floor line of the upper story. Then previously to dividing the rod, a height must be fixed upon for the step, this will, of course, be only an approximation to the exact height, which must be determined in the following manner:—With a pair of dividers, having their limbs extended to the intended height of the step, mark the

divisions upon the story-rod. If this distance exactly measures the rod, we have nothing more to do than divide by it, but if the distance does not exactly measure the rod, and if it is determined that the step shall not exceed this distance in height, the breadth of the dividers must be lessened, until by repeated trials the rod is measured. With the distance, thus found, divide the rod, the number of divisions resulting is the number of steps required.

5. The number of steps may be ascertained arithmetically, without referring to the story-rod, in the following manner :—Divide the height of the story by the height of the step, the number resulting is the number of steps to be employed.

Let, for example, the height of the story be ten feet six inches, and the height of the step seven inches ; reducing the height of the story into inches, we have ten feet six inches, equal to 126 inches, this number divided by 7 gives 18, or eighteen steps, the number required in the story.

But if, and this is frequently the case, a remainder is left after the division is performed, that is, if the given height of the step is not an equal part of the height of the story, another height must be found for the step by the following process :—Divide the height of the story by the given height of the step, take the whole number resulting from this division, and divide the height of the story by it, the number, whole or fractional, resulting, will be the height of the step.

Taking, for example, the height of the story ten feet ten inches and a half, and the given height of the step seven inches, we have by reduction, ten feet ten inches and a half, equal to 130.5 inches, this number divided by 7, gives 18.6 nearly ; dividing 130.5 by the whole number 18, we have 7.25, or seven inches and a quarter for the height of the step.

This process brings out the step higher than the given one. If it is intended not to exceed the given step in height, we have only to add one or more, as the case may be, to the whole number before the division is performed.

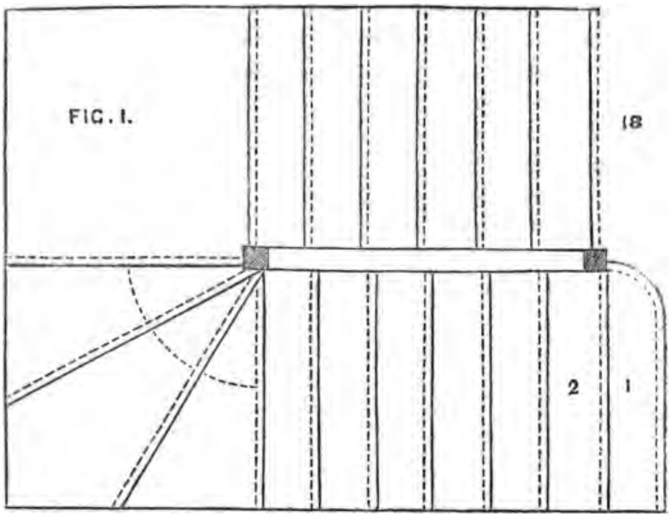
6. In cases where an even number of steps is required in the story, care must be taken to divide the story-rod into an even number of equal parts. The number of steps in a staircase cannot, however, in all cases be determined by consulting alone the story-rod, they will depend, in some measure upon the plan and the height of the story taken in conjunction with each other.

THE PLANS OF STAIRS.

7. The form generally made use of for the plans of stairs is that of a rectangular parallelogram. Other forms are sometimes employed, but they are chiefly confined to ornamental structures, or buildings of an irregular description. In all ordinary cases, the employment of the rectangular parallelogram for the above purpose is advisable. In laying down the plan of a staircase, due regard must be paid to the openings of the windows, door-ways, and the like. Where rooms are entered by door-ways from the half-space, calculations must be made for placing the floors of these rooms at their proper height, and this is generally required to be done long before the stairs are put up. In cases where half-spaces are employed, the upper and lower flights of the same story are generally made equal to each other in length.

8. The annexed figure is a plan of what is termed dog-legged stairs, commencing with a curtailed or bull-nosed step, and having one quarter of winder, and a quarter-space. The shaded parts represent sections of the newels, the dotted lines the risers, and the black lines the projections of the nosings of the treads.

9. For the purpose of illustrating the mode of laying down the plan of a staircase, we will consider fig. 1 as not determined. Proceeding on this supposition, let the height of the story be ten feet eight inches and a quarter, and the height of the step as nearly seven inches as the divisions of the story-rod will admit of. By proceeding as directed in Art. 5,



we have eighteen steps in the story, and the height of the step equal to seven inches and one-eighth, and, by Art. 2, we have the breadth of the step answering to this height, rather exceeding nine inches.

These things being determined, proceed to lay down the quarter-space and winders, as in fig. 1. Make the quarter-space rectangular, and its length and breadth equal to the length of the flyers, and make the quarter for the winders of the same dimensions as the quarter-space. Find the breadth of the winders by dividing the arc of a circle drawn through the middle of the treads, as shown in fig. 1 ; after which, draw the flyers of the upper and lower flights, making with the winders, quarter-space, and landing, eighteen steps.

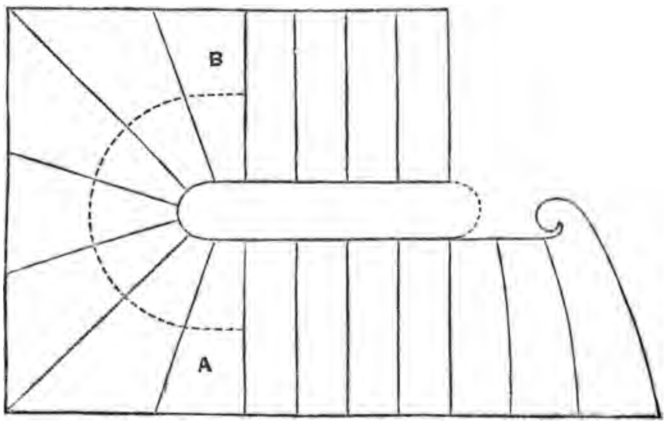
If, in laying down the plan as above, it is found that there is not sufficient room upon the landings, that is, if the flyers are found to extend too far, each flight may be shortened one step, by introducing winders in the place of the quarter-space. If this process does not bring the flights within the required limits, the height and breadth of the steps must be

altered, or an extra winder must be added, but care must be taken not to make the winders too narrow.

In laying down the plan of the winders, the section of the newel must first be drawn ; the nosing lines of the winders must then be drawn to the angles of the newel, as is shown in fig. 1 ; and the lines of the risers must be drawn at their proper distance behind the lines of the nosings, as is shown in the same figure by the dotted lines.

When the steps are less than two feet nine inches in length, the winders contained in a quarter of a circle ought not to exceed three in number, otherwise they become inconveniently small.

FIG.2.



10. Fig. 2 is the plan of a staircase of continued stairs commencing with curved winders and a scrolled step, and having winders connecting the upper and lower flights.

Stairs of this form are frequently employed in houses of the first and second class about the metropolis.

In Art. 9, the plan of the stairs is supposed to be made subservient to contingent circumstances ; but in those cases where elegance of form is an object, as in the principal stairs of large houses, the plans are usually determined upon pre-

viously, to the construction of the building, and provisions are made for them accordingly.

THE NOSING LINE.

11. The method of laying down the plan of the winders of continued stairs differs, in some degree, from that of dog-legged stairs, described in Art. 9. The nosings of the winders of continued stairs are made to follow a curved line for the purpose of giving a beautiful form to the wreathed portions of the hand-rail and string-board, both of which are made to follow the steps in curves, similar to that of the nosings, hence the importance of a well constructed nosing line.

Fig. 3 is an illustration of the method of determining the breadth of the ends of the winders in stairs of the form represented by fig. 2. In the plan fig. 2, the steps A and B

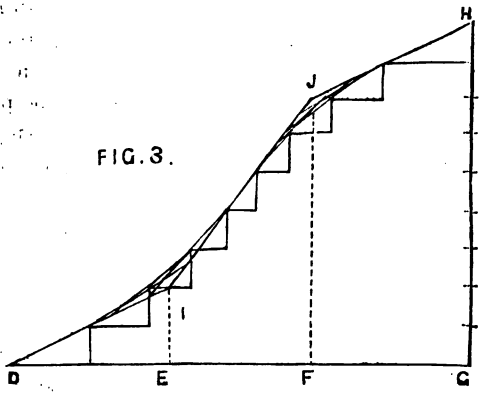


FIG. 3.

are called diminished flyers, their winding forms arising from accidental circumstances. The breadth of the winders and diminished flyers are determined in the following manner:—Draw the straight line D G, fig. 3, and upon the end G erect a perpendicular, G H; make G H equal in length to the height of four flyers and five winders; that is, equal in length to the height of nine steps, and divide it into nine parts. Make the

distance from G to F equal to the breadth of two steps, and make the distance from F to E equal to the circumference of the semi-circle around which the ends of the winders meet, and make the distance from E to D equal to the breadth of two steps. Erect the perpendiculars E I and F J, and make E I equal to the height of two steps, and F J equal to the height of seven steps; that is, to the five winders and the two flyers. Join the points D I, I J, and J H, and ease off the angles formed at I and J. The curve thus formed is called the line of nosings.

When the line of nosings is constructed the steps are easily determined as follows:—Through every division of the line G H draw parallels to D G; from the points where the parallels cut the line of nosings let fall perpendiculars; the point of intersection of each perpendicular, with its contiguous parallel, determines the breadth of the winders. Thus, through the first division of G H draw a parallel to D G, from the point where this parallel cuts the line of nosings; let fall a perpendicular, and the first step will be formed; again, through the second division of G H draw another parallel; from its point of intersection of the line of nosings let fall a perpendicular upon the first parallel, and we have the second step formed. By proceeding in the same manner, the whole of the steps may be determined.

It may be here noticed, that for the purpose of more clearly defining the line of nosings, the steps in fig. 3 are drawn to a larger scale than those of the plan, fig. 2.

12. It will be necessary, here, to explain the method of constructing the curves or easings made use of, at I and J, for the purpose of rounding off the angles of the line of nosings.

Let A B and B C, fig. 4, be two straight lines, forming an angle at B: make any number of divisions, 1, 2, 3, upon the line A B, make the same number of divisions upon the line B C, and join the points 1 1, 2 2, and 3 3; a curve drawn through the points of intersection of these lines is called a parabola. This curve frequently occurs in the construction of

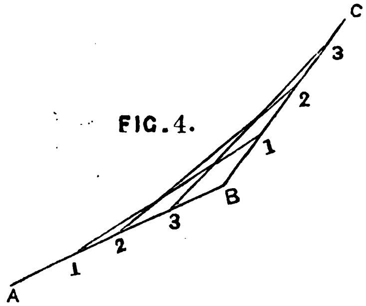


FIG. 4.

stairs, but fortunately its properties, which are difficult to be understood, need not be here considered; the construction of the curve, according to the foregoing directions, without regard to its nature, is all that is required to be known.

Other methods of reducing the angle to the curvilinear form are sometimes given, but the above is generally employed, and is applicable in all cases; we shall, however, just mention another. Measure from the point B, fig. 4, equal distances along the lines A B and B C; upon the points thus found erect perpendiculars; these perpendiculars will converge towards, and intersect, each other; their point of intersection is the centre of a circle of which the lines A B and B C are the tangents. With the centre as above found, and either of the converging lines as radius, draw an arc, this arc connecting the two lines A B and B C, is the curve employed.

THE SCROLLED STEP.

13. The first step of geometrical or continued stairs, is generally of an ornamental character, the riser and tread of which are terminated in a scroll form, similar to the first step in the plan, fig. 2. As this form is intended to correspond with the scroll termination of the hand-rail, it will be found advisable to design the scroll of the hand-rail previously to that of the step, and then to trace the plan of the step from it.

The method of describing the scroll will be treated of in the system of hand-railing; we shall, therefore, here only show the method of putting the parts of the step together, leaving the construction of the geometrical lines for the present.

FIG. 5.

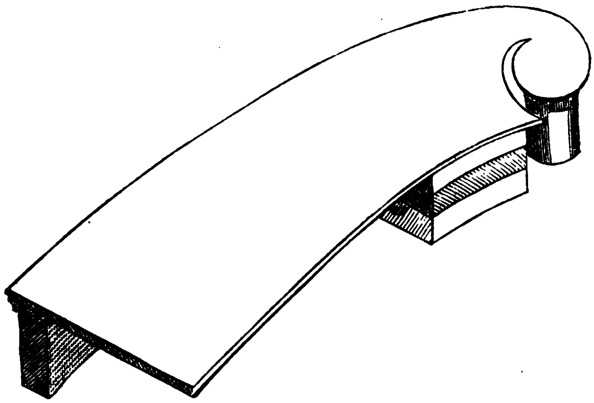
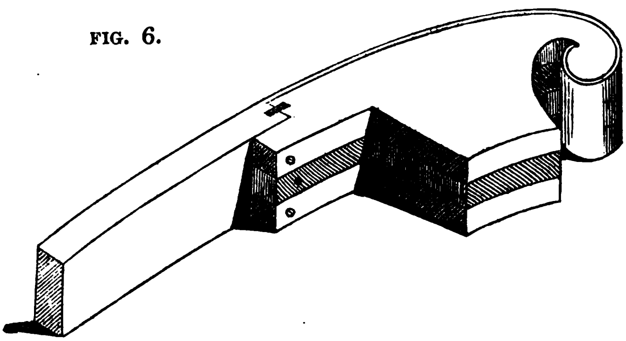


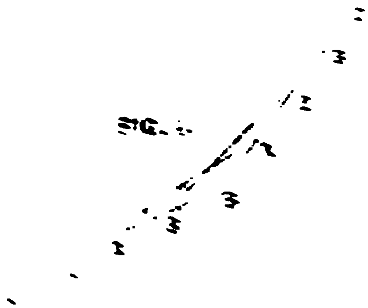
Fig. 5, is the representation of a step of the common form, employed for the commencement of the first flight of geometrical stairs, shown as it would appear when finished. In this example the riser is curved in the form of the hyperbolic spiral ; and the curved form given to the risers of the first two or three steps of geometrical or continued stairs, gives them a more graceful and finished appearance than they would otherwise have.

FIG. 6.



14. Fig. 6, is the form of the riser corresponding with the step, fig. 5, showing the mode of preparing the scrolled block. This block is generally made up of two or three thicknesses of

FIG. 4.



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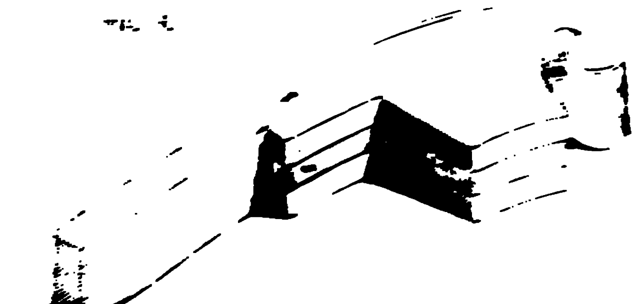


wood glued together, and veneered, as shown in the figure. The hollow or cavetto, which is employed beneath the nosing of the step, is worked from a board laid upon the edge of the riser, and cut to follow its curvature. The hollow and tread are then secured to the riser from the under side of the tread with screws and glued blocks, as may be required.

CONSTRUCTION OF THE STRING-BOARD.

15. THE STRING-BOARD is that part of stairs which serves to unite together the ends of the steps. It serves also to conceal the rough carriages which pass underneath and support the stairs, and, when well constructed, it forms one of the principal ornaments of the staircase. When flights are of considerable length the carriages made use of are large, and require a corresponding breadth of string-board to cover them. The double-faced or sunk string-board is in such cases necessary, for the sake of affording relief from the plain appearance that would otherwise be given.

16. The surfaces of the string-boards of dog-legged, and open newelled stairs, are in straight lines and occupy vertical planes; the string-boards of geometrical stairs are made to wind around the circular, the elliptical, and every variety of plan; they are also made to follow the undulations caused by the varying breadths of the winding treads.

String-boards are differently denominated close-strings, cut-strings, wreathed, and wall-strings. The close-string is generally finished with a returned bead upon its lower edge, and its upper edge is finished with a capping and moulding for the reception of the balusters. The cut-string has, generally, a bead upon its lower edge, and may be finished with or without brackets, according with the quality of the stairs for which it is designed. The wreathed string-board, like those mentioned above, has a bead upon its lower edge, and is generally finished with brackets; it may be either sunk to form a double face or left plain, but the sunk string is preferable for stairs of an ornamental character. The

wall-string is generally plain, having a bead or moulding upon its upper edge, corresponding with the moulding made use of for the skirting of the other parts of the staircase and landings.

17. The development of the ends of the steps, upon a plane, affords an accurate guide to the workman in the formation of the outline of the string-board. The mode of accomplishing this development is by a process the exact reverse of that explained in Art. 11. In fig. 3. Art. 11, the line of nosings is given to find the breadth of the winders; in the following process the breadths of the steps are given to find the curvature of the string-board. This of course only relates to the parts of the string-board that envelope the ends of winders, the string-boards of flyers are straight, and the mode of setting them out is consequently simple.

It is the practice of some workmen to construct their wreathed string-boards without laying down a development of the steps:—A solid block of wood, placed in a vertical position, is hollowed out to the form of the well-hole; or, in cases where the well-hole is large, several blocks are glued together, and the wreath thus prepared is joined to the straight parts of the string-board. It is then notched out on the upper edge to the form of the risers and treads, and its lower edge is wrought into a curved line at a parallel distance from the lower angles of the steps. This mode of constructing the wreathed string-board cannot be recommended, it is only admissible in inferior work. The veneered wreath, capable of the highest finish, and applicable in all cases, is more generally adopted, the mode of forming it will, therefore, be fully explained. It will, however, be necessary first to treat of the more simple forms of the string-board, commencing with that of dog-legged stairs.

18. Fig. 7 shows part of the close-string of dog-legged stairs enlarged, but similar to what would be required for stairs of the form shown in fig. 1. The triangular figure, A, is the

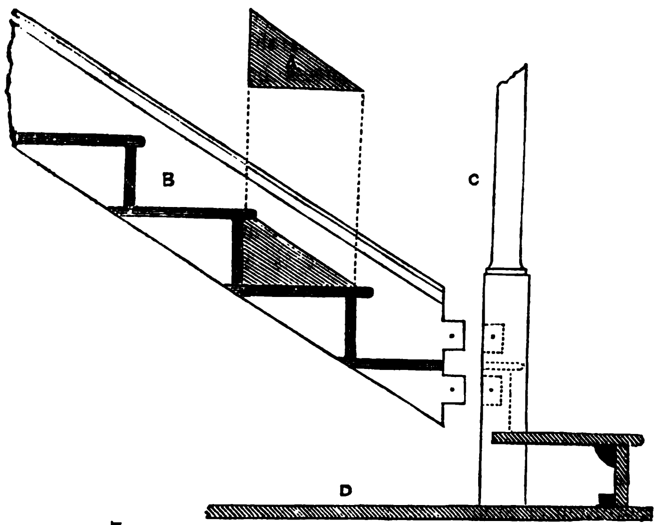


FIG. 7.

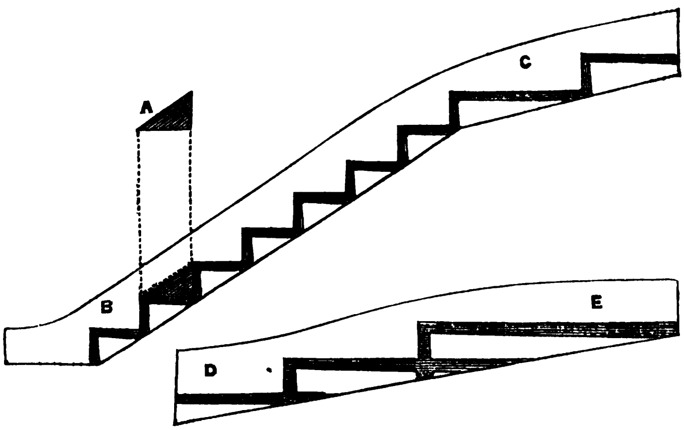
pitch-board, formed by making one of the sides of a right-angled triangle equal to the height, and the other to the breadth of the step. The pitch-board is applied in the following manner:—Let the distance, at which the steps are to be placed from the edge of the string-board, be determined upon; and through this distance let a parallel to the edge of the string-board be drawn; lay the oblique edge of the pitch-board along this line, commencing at the bottom end of the string-board, and draw lines by the other two edges of the pitch-board, marking out the first step. Remove the pitch-board, a distance equal to its own length, along the parallel line, and mark out another step; proceed in the same manner, until all the steps are completed. In fig. 7 the pitch-board, as applied, is shown upon the string-board B; and a representation of the newel, removed for the purpose of illustrating the method of joining it to the string-board, is shown at C. The other end of the string-board is joined to the upper newel in a similar manner.

A section of the floor and the bull-nosed step are shown by the shaded parts attached to the newel; and the dotted

lines show the position of the riser, and part of the tread of the next step. It is not usual in the inferior kinds of dog-legged stairs to employ carriages beneath the treads ; the string-board B is, therefore, drawn to admit merely the steps ; if carriages were introduced, the string-board would, in consequence, be required of greater breadth. In cases where carriages are not employed, the string-board ought not to be less than an inch and a half thick, and the grooves for the reception of the steps ought to be at least half an inch deep.

19. THE WALL-STRING is similar in its general character to the close-string ; it differs, however, in those parts that are contiguous to the winders. The mode of setting out the wall-string is the same as employed in setting out the close-string, and in general the same instrument, the pitch-board, is employed in some way or other in setting out every description of step.

FIG. 8.



The form of the wall-string that would be required for the lower flight of fig. 1 is shown at B C, fig. 8 ; A exhibits the pitch-board removed, and the application of it is shown upon the string-board B C. The wall-string of the return corresponding with the end of the winders and quarter-space is shown at D E.

The nosings of the treads are not shown in these examples, but the mode of tapering the grooves for the purpose of wedging the steps in the string-board is exhibited.

In regard to setting out the string-board for winders, the height of the step remains constant, but the breadth of the winders varies according to the obliquity of the angle formed by the wall and the nosings of the winders. This breadth is obtained from the plan, and is laid down upon the string-board in the same manner as we lay down the breadth of a common step in the straight part of the string-board. Having obtained the indentations of the winders, draw a line parallel to the nosings of both flyers and winders, this line will be the outline of the upper edge of the string-board.

Where the ends of the string-boards B C and D E meet each other in the angle, they must both be of the same perpendicular height above the tread, and the lower end of the string-board B C must be wrought into an horizontal line at the height of the skirting that it is intended to unite with it.

20. THE WREATHED STRING-BOARD, developed at B C, fig. 9, shows the form of that which would be required for the semicircle of winders in fig. 2. In constructing this development, commence with the flyers, and lay down the breadths of the winders, in order as they occur in the plan ; and for the purpose of obtaining the direction of the straight part of the string-board continue the flyers to the number of two or three, after the winders are developed. A line drawn parallel to the lower angles of the steps, forms the lower edge of the wreath. A trifling modification of the above is required where the lines drawn form an abrupt angle, merely to ease the whole into a gentle curve.

The wreathed string-board, measured from the lower angles of the steps, in a direction perpendicular to the curve of its lower edge, should be of equal breadth at all points. Workmen not understanding this, frequently fall into error in measuring the breadth of the string-board upon vertical lines, causing the wreath, where the winders rise abruptly, to be extremely contracted in its breadth.

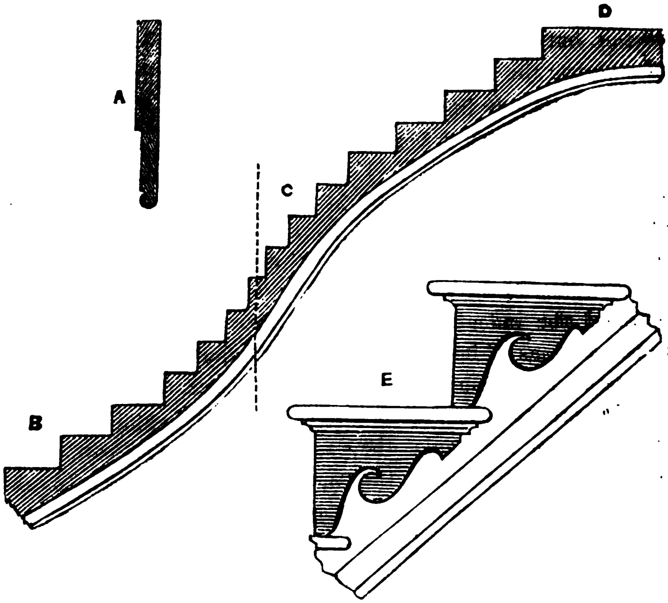


FIG. 9.

21. Having obtained the development of the wreath, according to Art. 20, a veneer must be prepared, upon which the development must be transferred. The middle dotted line C must also be transferred to the veneer. This line is drawn vertically through the middle line of the development, and is used as a guide, merely in laying the veneer upon the cylinder. The lower edge of the veneer must then be cut to the curve of the development, but the indentations of the steps must not be cut until the veneer, properly blocked, is taken from the cylinder.

22. The term cylinder, in staircasing, is applied to any prismatic solid, having the plan of the well-hole of the staircase for its base: with this qualification, wherever the term occurs, it must be understood.

Fig 10, is the common form of the cylinder employed in staircasing: the dotted line A B, drawn upon it, and dividing

the semicircle into two equal parts, serves as a guide in laying on the veneer of the wreath.

23. The cylinder being prepared according to Art. 22, and the veneer according to Art. 21, proceed to secure the veneer upon the cylinder in the following manner:—Lay the dotted line C of the veneer B D, fig. 9, along the dotted line A B of the cylinder, and secure it in this position by laying a slip or block of wood over it, in the direction of the line A B, and nailing the block to the cylinder. This being done, bend one end of the veneer downwards over the cylinder, and secure it by nailing on another block. Proceed in the same manner with the other end of the veneer, taking particular care to keep the dotted line C of the veneer over the dotted line A B of the cylinder.

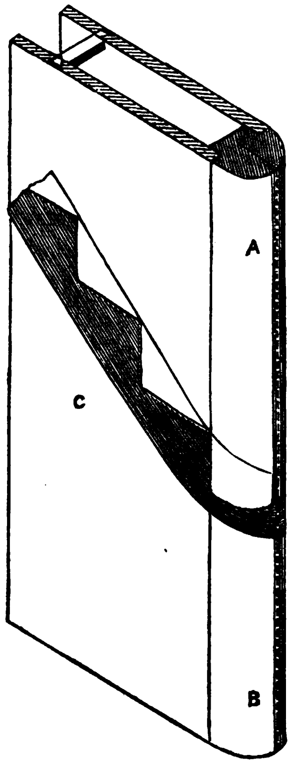


FIG. 10.

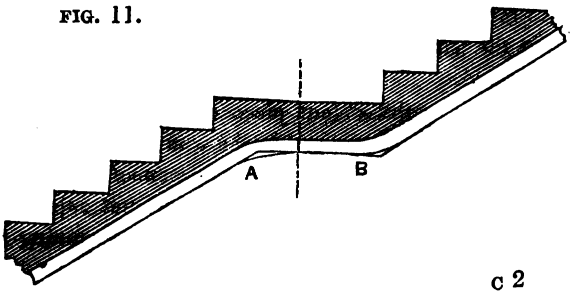
Having adjusted and secured the veneer upon the cylinder, proceed to glue blocks upon it, nailing them where requisite to the cylinder and to each other. When the glue has become sufficiently dry, work off the back of the blocks to an even thickness, and glue a strip of canvas over the whole. Withdraw the nails that secure the blocks to the cylinder, cut off the ends of the blocks to the curve of the veneer, and remove the whole from the cylinder. The indentations of the steps may now be cut out, according to the lines that were marked upon the veneer when in its developed state: the wreath thus prepared is

ready to be joined to the straight parts of the string-board. In treating of the development of the wreath, it was stated that two on three flyers should be laid down, for the purpose of finding the direction of the straight part of the string-board. Where this is done, the direction of the joint may be found by the application of the common square to the edge of the string-board, and in order to make the joint as little conspicuous as possible, it should be made at the lower angle of a step.

24. The section at A, fig. 9, is that of a sunk-string, showing the method of joining its parts with the groove and tongue, and the figure at E, exhibits the ends of two steps of continued stairs, with the application of the bracket to the string-board. In preparing for the bracket, the riser and tread are made to project the thickness of the bracket beyond the face of the string-board: the bracket is then mitred to the riser, and properly secured to the string-board with brads and glue.

25. In the annexed figure is developed a wreath, the form of which would be required at a half-space, connecting a progressive and a retrogressive flight. The part between A and B is kept horizontal, and the angles at A and B are rounded off as little as possible, for the sake of preserving the horizontal position of the lower edge of the string-board. This is necessary to be done or the soffit cannot be properly finished; the angles may be eased off, by the method shown in Art. 12, or by hand, as most convenient.

FIG. 11.

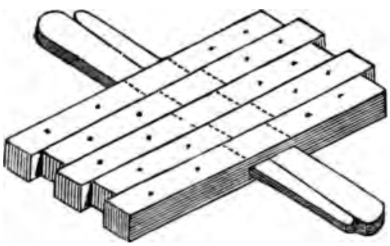


JOINING THE STRING-BOARD.

26. In joining the different parts of the string-board together, a simple and ingenious contrivance is employed :— Three or four rectangular blocks of wood, having a mortice hole in each, are placed side by side upon the back of the string-board over the joint ; these pieces are secured alternately to each part of the string-board, in such a manner that, by driving a pair of parallel wedges through the mortice, the parts of the string-board forming the joint are drawn together.

Fig. 12. represents a set of blocks and wedges, as they appear when put together upon the string-board. Five blocks are here shown, but in most cases it is not necessary to use more than two or three. When the joint is properly drawn up by means of the parallel wedges, the blocks are firmly screwed and secured to both parts of the string-board.

FIG. 12.



The above general directions, it is hoped, will enable the student to construct any description of string-board that can occur.

27. After the steps and string-boards are prepared, according to the foregoing directions, each flight is put together, leaving out the winders, which are fitted separately after the flights are fixed.

In fixing the stairs a stout piece of quartering, termed a pitching piece, is firmly wedged in the wall of the staircase at the termination of each flight, or at the commencement of the winders. This piece is intended to receive and support the rough carriages, which are pieces of quartering running lon-

gitudinally beneath the flights, serving for ceiling joists of the soffit and supporters of the stairs. Rough brackets are nailed beneath every step to these carriages, and they are connected to the treads and risers of the steps by gluing blocks upon them.

In the best constructed stairs, carriages are framed and firmly fixed into the wall beneath the winders; but in common practice, a piece of quartering, having one end wedged into the wall beneath each winder after the winders are fixed, the other end being secured to the wreath, is all that is generally employed as the absolute support of the step. Transverse pieces and glued blocks are introduced beneath the winders, depending upon the quartering fixed in the wall for their bearing and support. Precise rules cannot, however, be laid down in the department of fixing; local causes must ever rule; and the experience of the workman can alone direct him how to proceed.

Having fixed the straight flights and secured the string-boards to each other, proceed to fit in the treads and risers of the winders, commencing at the lower winder, fitting them and building them up one by one, until all are completed. Fix the quartering beneath the winders in such a manner that there may be no abrupt angles in the soffit. The soffit ought to be so constructed as to form a graceful line beneath the winders, neither abruptly curved, nor straight in one part and curved in another. Where half-spaces are employed, joists are framed and fixed to the walls, as in a common floor. The moulding or the bead of the wall-string, and the bead of the wreathed string, are generally put on after the stairs are fixed, cane rods being employed in the curves.

PART II.

THEORETICAL PRINCIPLES OF THE ORTHOGONAL SYSTEM OF HAND-RAILING.

ARTICLE 1. The chief difficulty in the construction of a hand-rail occurs in that part of it termed the wreath. If the wreath were composed of plain curves no difficulty could arise, but in winding around the well-hole of a staircase it takes the form of a curve of double curvature. To construct this curve in parts, and form it in wood without waste of material, constitutes the art of hand-railing.

Writers generally explain the art of hand-railing upon the supposition that the wreath, or that part of the hand-rail that winds around the circular spaces of the well-hole, is composed of parts of a hollow cylinder, equal in thickness to the breadth of the hand-rail, and in diameter to the diameter of the plan over which the hand-rail is to be constructed. The solid forming the wreath, when cut out of the plank by the method about to be explained, is no part of such cylinder, but having to be wrought into the cylindrical form previously to its being squared, we shall derive some assistance from considering it as cylindrical. Hence, a ready method of constructing the section of a cylinder, when the cylinder is cut in any direction by a plane passing through it, is obviously necessary.

The general form of the hand-rail is sufficiently known to obviate the necessity of going into a description of it, we shall, therefore, at once proceed to consider the cylinder and the geometrical lines in connection with it, following out the subject of hand-railing, by the consideration of problems necessary to complete the theory of the orthogonal system.

2. If a right cylinder, A B C D, fig. 13, is cut by a plane passing through it obliquely, the section will be an ellipsis, as C D E F.

3. If the cylinder, A B C D, stands perpendicularly upon an horizontal plane L M G H, the plane of the section, Art. 2, will cut the horizontal plane.

4. The common section of two planes is a straight line, therefore the common section G H of the planes E H and L H is a straight line.

5. A line, C K, drawn through the vertices C and D of the ellipsis, is at right angles to the common section G H, for a line drawn through D in the plane E F G H, and parallel

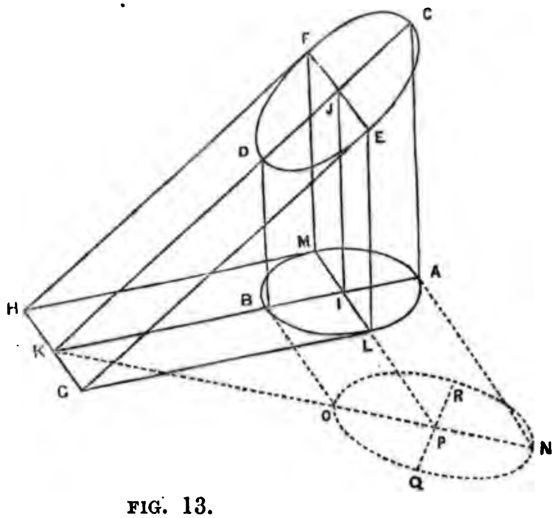


FIG. 13.

to G H, is a tanget to the curve at the vertex D; and the line C D drawn through the vertices of the ellipsis is the major axis, but the tangent at the vertex is at right angles to the major axis; therefore, G H being parallel to the tangent is at right angles to the major axis produced in K.

6. The line G H is at right angles to the line A K, drawn from the point K, through the centre I of the base of the cylinder. Consequently, the diameter L M of the cylinder, drawn at right angles to A K, or parallel to G H, is parallel to E F, the minor axis of the ellipsis. All ordinates, I M, I L, &c., drawn upon the base of the cylinder, parallel to G H, are therefore parallel, and equal in length to their corresponding ordinates J F, J E, &c., drawn in the ellipsis parallel to the same line G H. From this it will be seen, that when the common section G H of the two planes E H and L H is found, the section of the cylinder can be constructed.

7. Example:—Draw the line A N at right angles to A K; make the length of A N equal to the length of A C, and join the points N and K: the triangle A N K is equal and similar to the triangle A C K. Draw any number of ordinates, I L, I M, across the base A B of the cylinder, each parallel to the common section G H, and produce them to the line N K. At their intersection of the line N K, erect ordinates perpendicular to N K, and make the length of them equal to the length of their corresponding ordinates on the base, P R to I M, P Q, to I L, &c. Through the points R Q, &c., thus found, trace the curve N Q, O R: this curve is the section of the cylinder.

8. From Articles 6 and 7 it will be seen that a ready method of finding the common section formed by an horizontal plane and the plane of the cylindrical section, is of importance in constructing the section of a cylinder.

A plane can be made to pass through any three given points; if, therefore, any three points are given in the required section of the cylinder, and a plane is passed through them, the line formed by its intersection of the horizontal plane is the common section required.

In the following method of finding this section the horizontal plane is supposed to pass through the middle given point, one of the remaining points being above it, and the other below it. In which case the common section of the

two planes falls within the base of the cylinder, a circumstance necessary in the construction of the butt-joint lines of a hand-rail, by the methods to be explained.

9. The given points of the cylindrical section were in the old system of hand-railing called resting points, being the points upon which a plane would rest if laid upon the hand-rail when in a finished state. These points referred to the plan of the hand-rail, or to any horizontal section of the cylinder, are called the seats of the resting points. The points made use of in the principal examples of the orthogonal system are taken in the middle of the hand-rail.

10. A E C, fig. 15, is an horizontal section of a cylinder, and A E and C are the seats of three given points referred to in the section. Join the seats of the two remotest resting

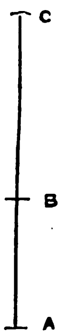


FIG. 14.

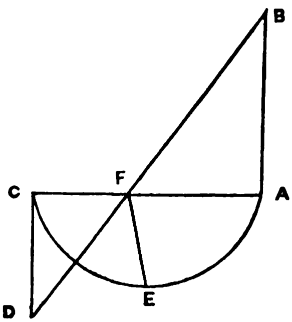
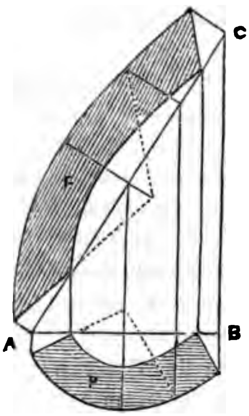


FIG. 15.

points, A and C, and let A B and B C, fig. 14, be the perpendicular distances of the given points from each other. Erect a perpendicular, A B, upon the point A, and let fall a perpendicular, C D, from the point C. Make the length of A B equal to the distance B C, fig. 14, and the length of C D equal to the distance A B. Join the points B and D, by the straight line B D, cutting the line A C in F. From the point F draw the straight line E F through the seat E of the

FIG. 18.

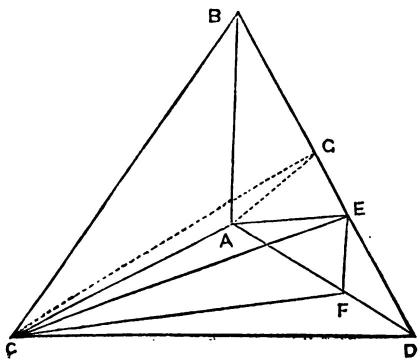


The quadrantal lines of this face-mould have been given by writers, as the joint lines of the wreath: they lie vertically over the plan lines of the joint, and, therefore, answer for a vertical or splice-joint. But the splice-joint is totally inadmissible in practice, the butt-joint being the only one ever employed.

THEORY OF THE BUTT-JOINT LINES.

14. PROBLEM. The triangle D A C, fig. 19, is an horizontal plane right angled at A, and D A B is a triangle right angled at A, the plane of which is perpendicular to the horizontal plane. C D B is an oblique plane cutting the horizontal plane in the line D C, and C A E is another oblique plane, passing through the horizontal plane in the line A C, and making a given angle, E A B, with the perpendicular A B. It is required to find the plan of the intersection of the oblique planes C D B and C A E.

FIG. 19.



From the point E, fig. 19, let fall the perpendicular E F upon the line A D and join the points F and C, the line F C in the horizontal plane D A C is the plan of the intersection.

For the line F C is drawn from C, a point in the intersection, to F a point in the perpen-

dicular let fall from the intersection, it is also in the horizontal plane D A C, it is, therefore, the plan of the intersection.

15. PROPOSITION. If the dotted line A G, in the plane D A B, fig. 19, makes right angles with B G, the line G C will also make right angles with B G.

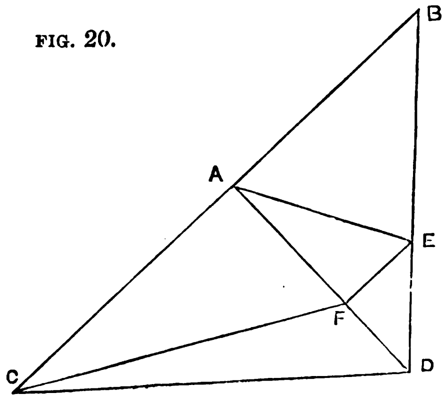
Let A G B be a right angle, then, since the planes D A C and B A C are each perpendicular to the plane D A B, their common section A C is also perpendicular to D A B, and the plane A G C passing through their common section is, therefore, perpendicular to D A B. The line B G, in the plane D A B is, by construction, at right angles to A G, the common section of the planes A G C and D A B, it is, therefore, at right angles to the plane A G C, and, consequently, to G A, a line in the plane A G C.

16. PROPOSITION. If A E B is less than a right angle, B E C is also less than a right angle.

Let A E B be less than a right angle; we have then the the two triangles B E C and B G C; the angle B E C is less than the angle B G C. Euclid, Prop. 21. Book I. But B G C is a right angle, B E C is, therefore, less than a right angle.

In the same manner it can be proved, that, when A E B is greater than a right angle, B E C is also greater than a a right angle.

FIG. 20.



17. PROBLEM. It is required to find the plan of the intersection E C, fig. 19, when the side D A B of the tetrahedron D A C B is developed on an horizontal plane.

Let D A B, fig. 20, represent the

side D A B of the tetrahedron, fig. 19, turned over upon the line D A as an axis, until it lies in the same plane as D A C. From the point A draw A E making the given angle E A B with the line A B, and from the point E let fall the perpendicular E F upon the line D A. Join the points F and C, the line F C is the plan of the intersection.

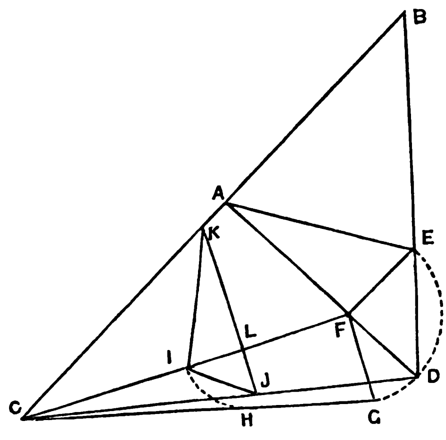
The plan of the butt-joint line is found by the help of this problem.

THE DIHEDRAL ANGLE.

18. PROBLEM. It is required to find the angle of inclination of the planes A E C and D E C, fig. 19.

Let the annexed figure D C A B be similar to the developed tetrahedron, fig. 20. From the point F draw F G at right angles to the line F C, make F G equal in length to F E, and join the points G and C. Through any point in the line F C draw J K at right angles to F C, and with L as a centre draw an arc, H I, touching the line G C in H, and cutting F C in I. Through the points J I and K I draw lines, the angle J I K is the angle of inclination of the two planes A E C and D E C, of fig. 19. which angle is termed the dihedral angle, and is that which the plane of the butt-joint of a hand-rail makes with the surface of the plank of which the wreath is composed; the plane D E C representing the surface of the plank, and the plane A G C or A E C the plane of the butt-joint.

FIG. 21.



19. It is proved, in Art. 15, that when the line A G, diagram, Art. 14, is at right angles to D B, the line G C is also at right angles to the same line D B. The line G C, when applied to the face-mould of a hand-rail, is a butt-joint line; obtainable upon the face-mould by a process to be explained.

20. The shaded quadrant A F J N K in the annexed figure, is the plan of a wreath lying in the horizontal plane D A C, and J B I L is the cylindrical section or common face-mould lying vertically over the plan in the oblique plane D B C. The radii of the cylindrical section J L and B I, as before stated, Art. 13, are not the butt-joint lines of the face-mould; they are, nevertheless, useful in aiding us to find the joint lines in a particular case.

It is evident, that, if the line G C, fig. 19, is at right angles to D B, it is also at right angles to any line that is drawn parallel to D B. In the annexed figure, we have the

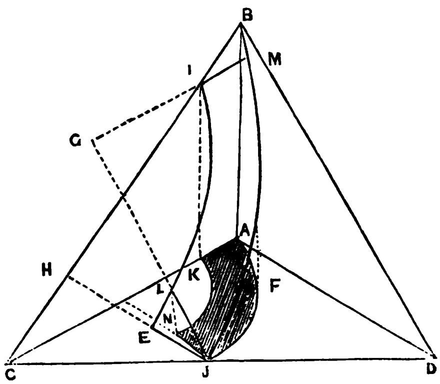


FIG. 22.

solid D A C B similar to the solid D A C B, fig. 19; we have, therefore, the line D A at right angles to A C, and J N, the radius of the end J of the quadrant, at right angles to A K, the radius of the end A of the same quadrant. The line D B is, by construction, vertically over the line D A,

and J L is vertically over J N; J L is, therefore, parallel to D B, and, consequently, any line drawn at right angles to J L is also at right angles to D B. If, therefore, the radius J L of the quadrant of the cylindrical section is produced to G, and at right angles to it the line G M is drawn, G M will be at right angles to D B. It is proved, in Art. 15, that when the angle B G A, fig. 19, is a right angle, B G C is also a right angle. If, therefore, in any case the angle B G A, fig. 19, is known to be a right angle, we shall have no occasion to develope the tetrahedron for the purpose of finding the plan C F of the intersection, as the intersection can itself be found, being at right angles to the line D B, or to the produced radius J G.

It is proved above, that G M, fig. 22, is at right angles to D B. G M or I M is, therefore, the intersection of the plane of the butt-joint and the surface of the plank; it is, therefore, a joint line of the face-mould J E M I.

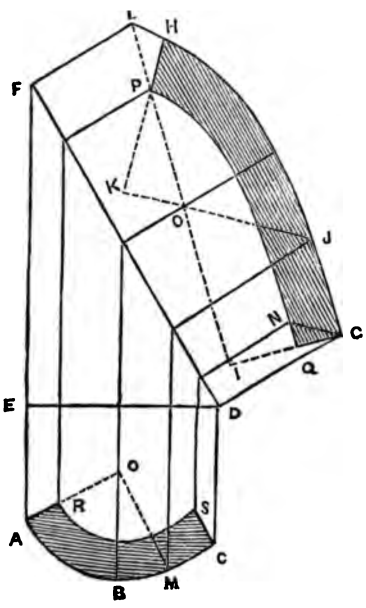


FIG. 23.

By the same means the joint line J E of the other end of the face-mould is found, being drawn at right angles to B H, the radius B I of the quadrant of the cylindrical section produced.

21. The following example shows the application of these lines to the face-mould of a wreath:—Let A B C represent the plan of one quarter of a wreath, and A E, B O, C D, the ordinates, the direction of which are determined as directed in Art. 11. The face mould P Q G H is traced out from the plan,

A B C, in the usual manner; the radii O J and O L of the section corresponding with O M and O A of the plan. Producing O J to K, and O L to I, and drawing the lines K H and I G, each at right angles to its respective radius, K H to K J and I G to I L, we have the lines H P and I G for the joint-lines of the wreath.

The reason for drawing the joint-lines through the points P and G is, that two of the resting points of a plane upon the winding surface of a wreath are at these points, and the face-mould in this example is supposed to be constructed to these points, or which is the same thing, to the surface of the plank. If the face-mould were constructed to the middle of the wreath, the joint-lines would be required to be drawn to the middle points of the lines P L and G N.

The application of the general problem, Art. 14, to the construction of the joint-lines of a wreath, of which the above example illustrates only a particular case, is treated of more fully in a subsequent article.

THEORY OF THE ORTHOGONAL FACE-MOULD.

22. In the preceding examples are shown methods of obtaining the section of a cylinder, and the application of it to the construction of the common face-mould of a hand-rail. The orthogonal face-mould, the nature of which we shall now explain, is employed merely for the purpose of determining the form of the least solid that is capable of containing within it the square wreath.

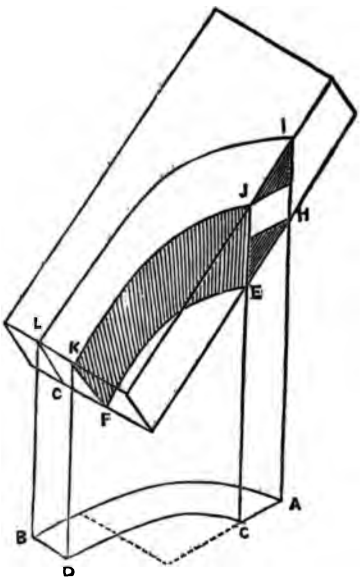


FIG. 24.

The common face-mould was originally the only one employed in the process of cutting out the wreath, but the solid cut out to the form of the common face-mould contains a greater quantity of material than is required in the formation of the wreath. The difficulty of applying the common face-mould to the plank, and the impossibility of ascertaining what part of the plank the wreath will require from the mere position of the face-mould, render it necessary that some other method should be employed.

23. In figure 24, is shown the outlines of a plank with the oblique solid required by the use of the common face-mould drawn within it. A B C D is the plan of a quadrant of a wreath, and E F L I is the oblique solid required. It will be seen that in cutting out this solid the saw must be held in a position parallel to the vertical side E K F J of the solid; the consequence of this is, that in some cases the saw cut is of great depth. The consequent amount of labour required in cutting out the solid will of course be proportionably increased with the depth of the cut, or with the length of the vertical line E J.

24. A rectangular solid may be cut out of the plank that will contain the square wreath as perfectly as the oblique solid shown in fig. 24. The accompanying diagram exhibits a solid of this description, with the end of the square wreath J H shown within it. In cutting out this solid, the saw is held perpendicularly to the surface of the plank.

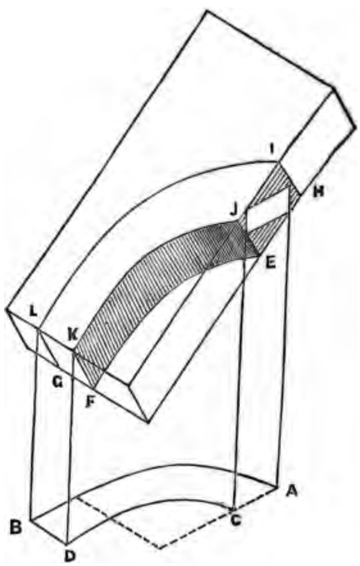


FIG. 25.

The advantages of the above, over the old method of cutting out the wreath, will be at once acknowledged when it is considered that the workman can, without hesitation, mark the whole of his wreaths upon the plank, and can truly estimate the quantity of material required to complete his hand-rail before he commences, which by the use of the common face-mould would have been impossible.

25. The method of constructing the orthogonal face-mould, which is not elliptical, and cannot therefore be formed directly from the plan, will now be explained. It may be observed, that the sides of the solid H G K J, fig. 25, unlike the sides of the solid in fig. 24, do not lie vertically over the plan A B C D, but merely contain the solid, from which the wreath can be formed. The face-mould of this solid may be constructed as follows :—Referring to fig. 13, let the triangle A K C be represented by the triangle A E F of the annexed figure; the line E F, representing the inclination of the plank, and let A B represent the plan of a wreath, the circular parts of which are described from the centre C. Upon the line A F draw a rectangular section of the square wreath, as is shown by the shaded part G. Draw the dotted rectangle G, containing the shaded section : this rectangle will be of the same size as the transverse section of a rectangular solid that will contain the square wreath. From the middle of that side of the dotted rectangle that lies in

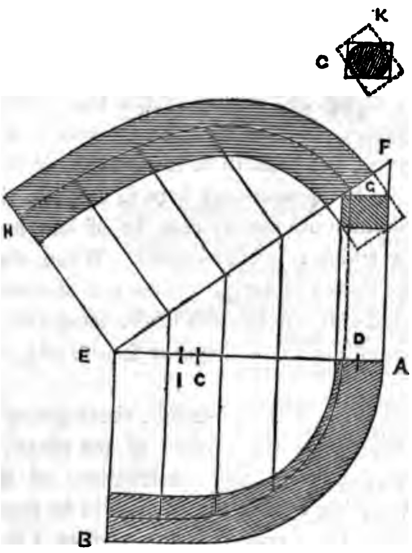


FIG. 26.

the line E F let fall a perpendicular line upon A E, and from D, the middle point of the breadth of the plan, extend the compasses to the centre C. Remove the compasses along the line A E until the point that was at D reaches the point of intersection of A E by the dotted line let fall from E F, and cross the line A E at I. Then, with I as a centre, and the compasses extended as above, describe an arc upon the plan A B, from this arc trace the curve H G: this curve is the middle line of the orthogonal face-mould. Set off half the breadth of the dotted rectangle G from each side of this curve. The figure H F, thus constructed, is the orthogonal face-mould of a wreath, the section of which is G and the plan A B. The solid cut out by this face-mould is similar to that exhibited in diagram 25, and is sufficiently large to admit of the wreath being perfectly squared within it.

26. Hand-rails when finished have generally their arrises rounded off, their general form approaching to that of an oval. From this circumstance, it will be seen that the face-mould may be of less breadth than that just found, as is shown at G K, fig. 26, where within the section of a square wreath is given a moulded section; the side G K of the dotted rectangle giving the breadth of the orthogonal face-mould.

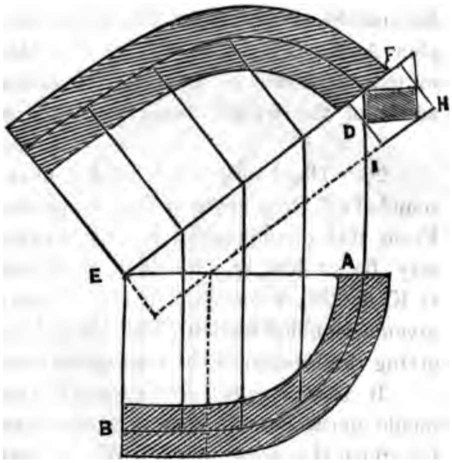
It is necessary here to remark, that the orthogonal face-mould must, in no case, be of less breadth than the hand-rail for which it is constructed. When, therefore, the side G K of the dotted rectangle comes out shorter than the breadth of the hand-rail, the breadth of the hand-rail must be taken for the breadth of the orthogonal face-mould.

27. The face-mould above given is constructed for application upon the surface of the plank, but from the following considerations the construction of it may be simplified:—Referring to diagram 25, it will be seen that all sections of the solid H L, parallel to the surface I K L, are similar to each other, and that the orthogonal face-mould is similar to these sections. In diagram 26, all sections of the dotted rectangle G that are made parallel to E F are equal in length to each

other, and to the breadth of the orthogonal face-mould. We may, therefore, construct the face-mould to the middle of the solid, of which the dotted rectangle is a section, instead of constructing it to the surface of the plank, and the curve from which we trace it will then pass through the middle of the plan.

EXAMPLE. Having drawn the curve A B, fig. 27, in the middle of the plan, draw the shaded section D H equal in size to a rectangular section of the square wreath. Upon the line E F draw a rectangle inclosing the shaded section: the side H I of this rectangle will be equal in length to the breadth of the orthogonal face-mould; and the side H F, to the thickness of the plank necessary in the formation of the wreath.

FIG. 27.

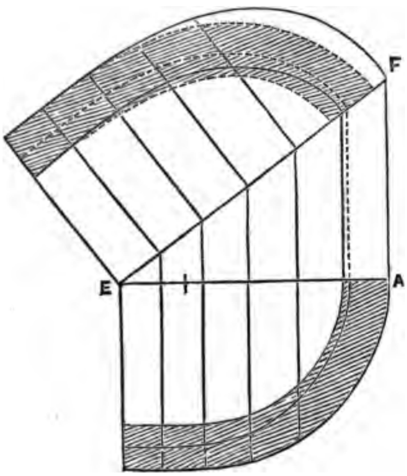


28. The application of the orthogonal face-mould to the plank for the purpose of marking out the solid containing the wreath, is a task of no difficulty; the mould is marked upon the opposite sides of the plank, so that the dihedral angles of the solid are right angles, or, in other words, so that a transverse section of the solid is rectangular.

THE ORTHOGONAL SOLID.

29. Having cut out the solid as above directed, our next object is to bring it into the cylindrical form, and for this purpose the common face-mould is required. The construction of the common face-mould is shown in Art. 13, but for the purpose of accomplishing the above-named object by a peculiar method, the ordinates employed in tracing out the orthogonal face-mould are made use of, at the same time, in tracing out the common face-mould. This is done by prolonging them across the plan, as is shown in fig. 28, where the shaded part shows the orthogonal, and the black lines the common face-mould. The small portion of the line E F that lies between the curve F and the shaded face-mould, is shown in fig. 27, by the side F, of the small triangle F; it is the distance that the common overhangs the orthogonal face-mould at that point. From the above premises, we shall point out two methods of bringing the orthogonal solid into the cylindrical form.

FIG. 28.

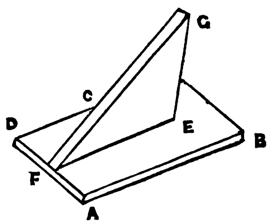


30. The first method:—Lay the common face-mould upon the upper side of the solid, in a position similar to that shown by the black lines in fig. 28, where the common overhangs the orthogonal face-mould at F, and mark the outlines of the face-mould upon the solid. Turn over the orthogonal solid, lay the common face-mould upon it, and slide it parallel to itself, in the direction of the hypotenusal line towards E, until it overhangs the concave or inner side of the solid, in

the same manner that it overhung the convex side in the former position, and mark the face-mould upon it. The solid must then be cut away obliquely to these marks, giving the cylindrical form to the wreath. Parts, however, of the solid fall short of the common face-mould, but where the face-mould overhangs the solid on one side, on the opposite side the solid overhangs the face-mould in the same degree.

31. The other method of reducing the orthogonal solid to the cylindrical form is as follows :—In the small diagram annexed, A B C D is a thin parallel board or veneer, square at the ends; upon this veneer is fixed an angular block E F G. The side E F of the block is placed parallel to the edge A B of the veneer, and the angle E F G of the block is made equal to the angle A E F of fig. 28. The veneer with the block thus attached is then turned over, the edge F G of the block resting upon the drawing, fig. 28, and the end A D of the veneer lying parallel to the ordinates of the section, with the angular end of the block towards F. If it is required to form the concave side of the wreath, the angle D of the veneer is brought into contact with the concave curve of the common face-mould, the veneer and block are then slid along the drawing, with the end A D of the veneer always kept parallel to the ordinates, and the angle D always in contact with the curve of the common face-mould. In sliding the veneer along the curve in the manner described, there will be found parts of the rectangular solid that will intercept the course of the straight edge D C. These parts must be cut away, so as to make the solid coincide with the straight edge of the veneer, which being done, the concave side of the wreath will be formed.

FIG. 29.



32. A similar process is employed in the formation of

the convex side of the wreath :—The veneer and block being removed to the outer, or convex side of the solid, the end A D of the veneer is held as before, parallel to the ordinates, while the angle A is moved along the outer curve of the common face-mould, causing the edge A B of the veneer to trace out the convex side of the wreath.

33. The nature of the above process may be understood by the following considerations :—Imagine the plank out of which the wreath is cut to be inclined at its proper angle over the plan, which angle is, in fig. 28, A F E. By Art. 31, the angle E F G of the block attached to the veneer is made equal to the angle A E F in diagram 28, or to the complement of the angle of inclination of the plank. From this arrangement it will be seen that, if the edge of the block is brought into the same plane as the surface of the plank, while the square end of the veneer is kept parallel to the horizontal ordinates, the edge of the veneer will be vertical, and will consequently trace out the vertical side of the wreath when moved along the curve of the common face-mould.

34. An illustration of the method of reducing the orthogonal solid to the cylindrical form, as described in Art. 31, is shown in the annexed diagram. The veneer is applied to the concave side of the solid, and the solid is shown with its inner arris worked off, forming the concave side of the square wreath. It will be seen that while the angular block rests upon the drawing, and the veneer is held parallel to the ordinates, the edge of the veneer traces out the form of the cylindrical solid.

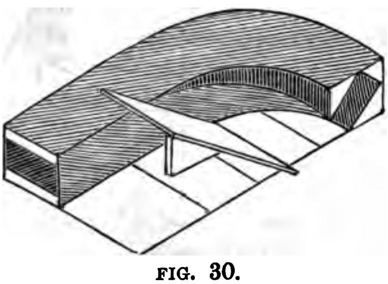


FIG. 30.

35. A discrepancy will appear to have occurred in

diagram 27. The middle of the shaded section of the wreath does not correspond with the line A D, connecting the middle lines of the plan and the orthogonal face-mould. This is, however, of no consequence, the section may be drawn upon any part of the line E F, its use being merely to determine the breadth of the orthogonal face-mould, and the thickness of the plank necessary for the wreath; by the above arrangement it is kept clear of the ordinates and all other lines.

36. The following example shows the construction of the orthogonal face-mould to the plan A B, fig. 31. The shaded section J K of the square wreath, is drawn upon the line B K, the angle K coinciding with the hypotenusal line G K. The line J H drawn parallel to G K, shows the thickness of plank necessary to construct and perfectly square the wreath. The oblique figure H G is the form of a section of the solid that would be required if the wreath were to be cut out by the common face-mould, and I K J L is a section of the required orthogonal solid, containing within it the shaded section of the wreath. The triangles J L G and K I H, show the quantity of material contained in the solid cut out by the common face-mould, more than is required for the orthogonal solid at the same point of the wreath.

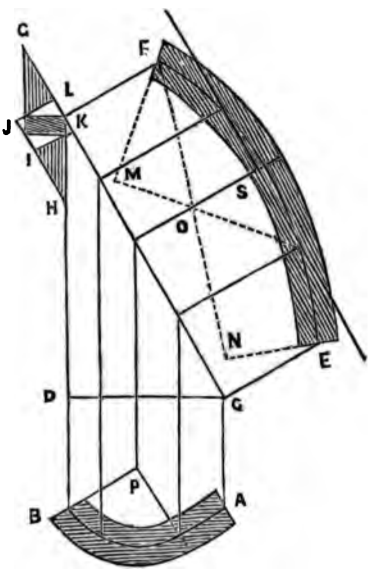


FIG. 31.

APPLICATION OF THE FACE-MOULD.

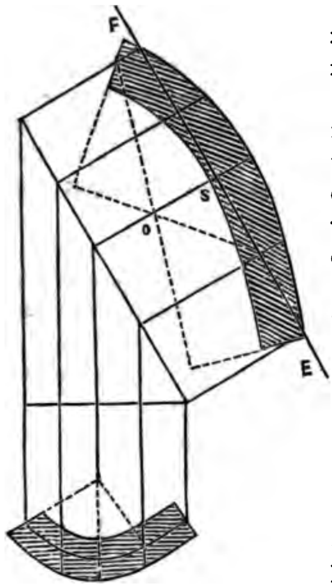


FIG. 32.

37. The annexed diagram, fig. 32, exhibits the common face-mould constructed to a plan similar to the plan A B in fig. 31. The line E F drawn upon it parallel to the hypotenuse is for the purpose of determining the relative positions of the common and orthogonal face-moulds, or of applying the common face-mould to the orthogonal solid, in the manner described in Art. 30. In diagram, Art. 36, the line E F drawn upon the orthogonal face-mould corresponds with the line E F in the annexed figure, each line being drawn parallel to the hypotenuse G L, and at the same distance from it.

38. In referring to diagram 31, it will be seen that the section J K of the orthogonal solid, occupies the middle part of the section G H of the oblique solid. L G is the distance that the convex side of the common face-mould, applied to the upper side of the orthogonal solid, overhangs it at the vertex of the cylindrical section, and H I is the distance that the concave side overhangs that of the orthogonal solid when applied to the lower side of the solid.

39. In figures 31 and 32, the line O S is drawn through the centre O of the elliptical quadrant across the two face-moulds and intersects the line E F in S. In bringing the orthogonal solid into the cylindrical form the lines E F and O S transferred from the orthogonal face-mould to the solid

cut out by it, serve as a guide in the application of the common face-mould to the solid.

The distance between the middle of the common and orthogonal face-moulds at the vertex of the cylindrical section is the distance that the line O S, of the common face-mould, is kept above or below the line O S of the orthogonal solid when applied to the upper or under side of the solid. The common face-mould being slid upwards or downwards along the line E F to the above-named positions, its place upon the orthogonal solid is determined, and the solid is wrought into the cylindrical form accordingly.

40. The distance of the middle of the two face-moulds from each other is obtained in the following manner :—Divide the side of the section J I, fig. 31, into two equal parts ; divide also the side J H of the oblique section into two equal parts : the distance between these divisions is the distance that the line O S of the common face-mould is slid upwards towards F on the upper side of the solid, or downwards towards E on the under side of it, accordingly as the face-mould is applied. The annexed figure shows on a larger scale the method to be adopted for the purpose of finding the above distance :—G H, fig. 33, is a section of the oblique solid, as shown in fig. 31 ; the section R S of the orthogonal solid drawn within it contains a section of the square wreath similar to that shown in the above diagram. The side of the section of the orthogonal solid is divided into two equal parts in the point O, and the side H M of the oblique section is divided into two equal parts in the point Q ; the distance between the points O and Q is the distance sought.

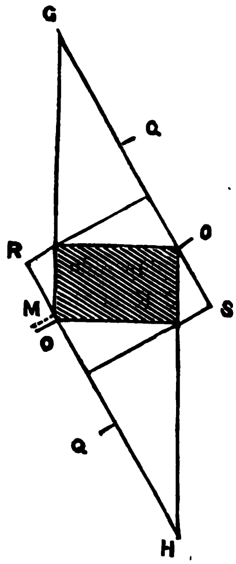


FIG. 33.

SQUARING THE WREATH.

41. Having obtained the vertical sides of the wreath, its upper and lower surfaces may be found by the application of the common square.

When resting points are employed in the construction of the common face-mould let those points be strictly attended to and preserved in the surface of the wreath, working off the superfluous material from the opposite side of the plank.

If the face-mould is constructed to the middle of the plank, the superfluous material must be worked off from each side, leaving the wreath in the middle of the plank. In applying the common square, care must be taken to hold the stock in a vertical position, or, in other words, parallel to the axis of the cylinder.

The three given points through which the face-mould is made to pass, determine exactly corresponding points of the wreath; we are therefore left merely to determine the form of the wreath between these points. This was formerly done by the application of a mould, termed a falling-mould, to the vertical sides of the wreath. But a little attention will enable the student to dispense with the use of the falling-mould for this purpose altogether. The falling-mould has, however, to be employed in the construction of a wreath.

CONSTRUCTION OF THE FALLING-MOULD.

42. In the construction of the face-mould of a wreath, it is necessary to develope the nosing line of the steps upon a plane, for the purpose of obtaining the different heights through which the wreath passes. The nosing line is constructed over the middle line of the plan of the wreath, and the figures formed by lines drawn at half the thickness of the hand-rail distant from each side of it is termed the falling-mould.

The shaded figure E L D F, fig. 4, plate 1, is a falling-mould, constructed over quarter-spaces, where the developed

middle line of the plan of the wreath that winds around the end of a quarter-space is equal in length to the breadth of a step. The falling-mould produced under these circumstances is straight, it is therefore in its most simple form. Where angles occur in the nosing line, the falling-mould is formed into gently undulating curves, termed easings; these easings are effected in the same manner as the easings of the string-board, shown at fig. 4, of Part I.

43. In fig. 4, plate 1, A B C is the plan of a wreath, the lines 1, 2, 3, 4, 5, are the risen lines of the steps, 2 3 and 3 4 are the quarter-spaces, and the lines A, B, and C, are the plans of the joints of the wreath. It is necessary to determine the places of the joints upon the falling-mould for the purpose of accurately constructing the face-mould:—Produce the middle joint-line B of the plan to the point D, cutting the middle line of the falling-mould in D; a line drawn through D, at right angles to the falling-mould, gives the place of the middle joint.

The places of the joints A and C are determined upon the falling-mould at E and F, by obtaining the length of the middle-line of the plan from A to B, or from B to C. This length being marked upon the line G H each way from the middle line, B D gives the points G and H. Lines drawn at right angles across the falling-mould at the points E and F, where the perpendiculars erected upon G and H cut the middle line of the falling-mould, are the places of the joints.

THE USE OF THE FALLING-MOULD.

44. The use of the falling-mould is, as before stated, to determine the points through which the wreath passes; these points being found, a cylindrical section, determined by the plan of the wreath, is made to pass through them: this section is the common face-mould of the wreath.

45. In referring to Art. 10, Part II, it will be seen that three points are necessary to determine the cylindrical section.

In hand-railing, a separate section is constructed for each quadrant of the wreath, and the heights of the separate sections are determined by the parts of the falling-mould answering to each quadrant of the plan. In the example before us, the parts of the falling-mould answering to each quadrant of the plan are determined by the perpendiculars G E, B D, and H F; the part E D of the falling-mould answering to the quadrant A B, and the part D F to the quadrant B C.

46. The parts of the falling-mould determined as above, are subdivided in the following manner:—Through the point D draw D I parallel to G H, and produce G E to I; divide the line D I into two parts in the point J, and let fall a perpendicular J L cutting the middle line of the falling-mould at L; from the point L draw L K parallel to D I, cutting E I in the point K; the points E, I, and K, are the heights of the three points of the cylindrical section.

The subdivision of the other part of the falling-mould is not, in this example, necessary, as it is exactly similar to the already divided part. It may be taken as a general rule that, when the steps of stairs are alike in both quadrants, the falling-mould of both quadrants is similar but reversed, and consequently the same face-mould reversed will answer for both quadrants of the wreath. The falling-mould, in such case needs only to be divided for one quadrant.

47. It is necessary here to observe, that the point of division of the line D I, fig. 4, plate 1, must be determined by consulting the middle line of the plan. In the example given in the last Article the developed middle line D I is divided into two equal parts, but this is not in all cases to be done. The point J ought to be in some part of the developed curve distant from the springing of the curve, at least one-third of the length of the curve developed. Attention to the above circumstance is of the utmost consequence in the construction of a wreath; the position of the middle point, or division, governs entirely what is termed the springing of the plank, and consequently the form of the wreath.

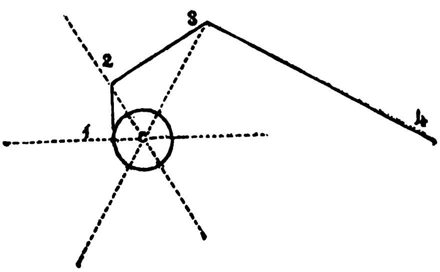
It may be just noticed, that in all the examples given we have divided the developed middle line of the plan into two equal parts, and when the straight part of the wreath is short in comparison with the curved part this may be done. But if the straight part of the plan is long in comparison with the curved part, the above remarks must be strictly attended to, the point of division must be decidedly in the curve.

CONSTRUCTION OF THE SCROLL.

48. The lower end of a hand-rail is generally terminated in a spiral; this may be either vertical or horizontal, in either case it is termed a scroll. Numerous methods of constructing the scroll are given by different writers, to suit the various cases that occur; the adaptation of the equiangular or logarithmical spiral to the purpose will, however, alone be here given. The simplicity of its construction, and the facility with which the curvature of the scroll can be regulated by it, give it claims upon our notice which other methods do not possess.

49. To construct the equiangular spiral:—Describe a circle, and divide it by any number of radii: then, from a point where a radius cuts the circle, draw an ordinate at right angles to the first radius, and cutting the second radius in some point. From the point where this second radius is cut by the first ordinate, draw another ordinate at right angles to the second radius, and cutting the third radius in the same manner that the first ordinate cuts the second radius. Proceed in the same manner with the next ordinate and radius, and so on, finding points in the radii. The points where the radii are cut by the ordinates are points in the spiral.

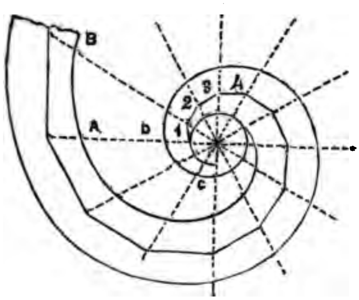
FIG. 34.



In the preceding diagram is exhibited the above method of finding points in the spiral; the lines 1 2, 2 3, 3 4, are the ordinates drawn at right angles to their corresponding radii, and the points 1, 2, 3, 4, are points in the curve.

50. To adapt the above spiral to the scroll of a hand-rail, we must proceed as follows:—Draw a circle equal in diameter to the thickness or breadth of the hand-rail, accordingly as a vertical or an horizontal scroll is required. The annexed figure is constructed for an horizontal scroll, the diameter of the circle is therefore made equal to the breadth of the hand-rail. Having described the circle, proceed to draw the radii, which in the present example are twelve. The spiral curve drawn through the points of the radii determined by the ordinates, is the middle line of the scroll.

FIG. 35.



Set off half the breadth of the hand-rail from each side of this middle line, and draw curves through the points thus found: the figure produced is the scroll.

The parallelism of the concave curve of the scroll to the spiral is continued until it meets the small circle in the centre of the scroll, but the parallelism of the convex curve is not continued beyond the point D, as shown in fig. 35. Upon the radius that is employed for the starting point of the spiral is commenced the convergence of the convex curve of the scroll towards the small circle; this convergence is accomplished as follows:—Proceed to find points in the radii towards C, by drawing ordinates in a contrary direction to those given for the purpose of finding the spiral. These ordinates being continued until they meet the small circle give the convergence required.

51. The curvature of the logarithmical spiral may be regulated either by employing a greater or less number of radii, or by making the angle formed by the radii and ordinates greater or less than a right angle. Spirals of any magnitude, from the most minute to those of infinite extent, may by the above method be constructed. In the example of the construction of the scroll above given, twelve radii are employed; it will, however, in most cases, be necessary to employ sixteen.

The scroll may consist of any number of revolutions, or it may be only one, or even a part of one revolution, the spiral being cut off at any point to suit the exigency of the case. In uniting the scroll to the straight part of the hand-rail, we may consider the straight part as a tangent to the curve; the joint ought not, however, to be made at the union of the two lines, but in the straight part of the hand-rail, at some distance from the curve.

PART III.

PRACTICAL ILLUSTRATIONS OF THE ORTHOGONAL SYSTEM OF HAND-RAILING.

HALF-SPACE, LEVEL-LANDING, AND SCROLL.

ARTICLE 1. The most simple example that occurs in the construction of a wreath is that in which the vertex of the cylindrical section corresponds with the vertex of the wreath. The radii of the cylindrical section are, in this case, the butt-joint lines of the face-mould, and they lie vertically over the joint-lines of the plan. The above is the case with the wreaths of half-spaces, level-landings, and the like, the face-moulds of which, except in very large well-holes, are inclined to the bevel of the pitch-board.

2. The plan of a wreath for a half-space is shown at A, fig. 5, plate 2, and the plan of a wreath for a level landing is shown at B, fig, 5, plate 1. The face-moulds of both these examples, are similar to each other, and are constructed as follows :—Upon the pitch-board G, fig. 6, plate 1, draw the shaded section of the square wreath, and upon the hypotenuse draw the dotted rectangle containing the shaded section, as shown upon the pitch-board. The length of that side of the dotted rectangle that lies parallel to the hypotenuse of the pitch-board is equal to the breadth of the orthogonal face-mould. The middle line of the orthogonal face-mould is traced from the middle line of the plan to the oblique side of the pitch-board, and the breadth of this face-mould, determined as above stated by the dotted rectangle G, is set off at E F.

3. The common face-mould in the above example may

be traced out from the plan with the same ordinates that we use in tracing out the orthogonal face-mould; the ordinates of the plan are drawn at right angles to the base, and those of the face-mould to the hypotenuse, of the pitch-board.

The difference between the common and orthogonal face-moulds is in these examples so small that it is not necessary to construct them both; the construction of the orthogonal face-mould may, therefore, be omitted, and the solid may be cut out rectangular, with a trifling augmentation of breadth, to the curves of the common face-mould.

The application of the common face-mould to the orthogonal solid, when the solid is cut out, may be understood by a reference to the sectional drawings on the pitch-board at G. These drawings show the different positions of the common and orthogonal face-moulds in relation to each other. The common face-mould applied to the upper side of the solid will overlap it at the vertex of the cylindrical section, just as much as the hypotenuse of the pitch-board projects beyond the dotted rectangle at the same point, and this face-mould applied to the underside of the solid falls short of it at the vertex of the cylindrical section, as much as the shaded section of the square wreath at G falls short of the lower side of the dotted rectangle.

4. The bevel that must be applied to the edge of the orthogonal solid for the purpose of determining the positions of the common face-mould in its application to the upper and lower sides of the solid is the angle at E, fig. 6, plate 1, formed by the vertical side of the pitch-board and the hypotenuse.

The butt-joint lines of the face-mould in these examples are traced from the plan, as shown in the diagram, and the same face-mould reversed serves for both the upper and lower quadrants of the wreath.

5. Fig. 4, plate 3, shows the method of tracing out the common face-mould of the scroll. A B C is the plan of the scroll, C D E the pitch-board, and F G the face-mould. The orthogonal face-mould may be traced out from a middle line

drawn upon the plan, but, as in the last example, Art. 3, the difference between the common and orthogonal face-moulds is so small that it is not necessary to trace out both. The bevel D E C, as in the former example, is that which is applied to the edge of the solid, for the purpose of determining the place of the face-mould upon it. It is hardly necessary to observe that the bevel D E C must be applied upon the solid in the straight part of the face-mould towards C E.

The place of the joint B of the scroll, if not previously fixed upon, may be determined as follows:—Draw the lines B B and J H, fig. 5, plate 3, and make the distance between them equal to the thickness of the plank out of which the block of the scroll is to be cut. Draw A A distant the thickness of the scroll above the line J H, and draw the pitch-board B K I upon it, easing off the angle at K. The figure A K I is the falling-mould of the scroll. From the point K, where the upper side B B of the plank intersects the upper edge of the falling-mould, draw the line K L. K L will be the place of the joint upon the falling-mould. Wrap the falling-mould around the block of the scroll when it is cut out, and the place and direction of the joint will be easily determined upon it from the joint-line K L. A perpendicular let fall from the middle of the joint-line K L upon the plan, when the mould is wrapped upon the block, determines the place of the joint B, fig. 4.

In the case of winders at the commencement of a flight, as in the plan, fig. 2, Part I, the scroll rises more abruptly than in the example just given. The rule given, in Art. 5, for finding the place and direction of the joint, answers in this case as well as in that, the place of the joint approaching the point A of the plan. If the scroll rises very abruptly, it may be found necessary to use thicker materials, or to cut out the block to an oblique mould, elevating it at the point B.

CONSTRUCTION OF THE MOULDS OF A WREATH FOR A QUARTER-SPACE.

THE FALLING-MOULD.

6. A B C, fig. 4, plate 1, is the plan of a wreath, and the fig. 1 3 5 is the plan of the steps ; 2 3 and 3 4 are quarter-spaces, the circular ends of which, developed at the middle line of the plan A B of the wreath, are equal in length to the breadth of a common flyer. The steps and quarter-spaces are developed upon the line G H, and the falling-mould E D F is drawn parallel to the nosings or angles of this development. It may be here remarked that it is not necessary, in any case, to construct more than the middle line of the falling-mould. It is, however, conceived, that a clearer idea of the form of the wreath may be gained by giving the whole of the falling-mould ; it is, therefore, given entire.

The line G H is the development or stretchout of the middle line of the plan A B C, the joint A corresponding with the point G, the joint B with the point 3, and the joint C with the point H. The perpendiculars erected upon the points G, 3, and H, and cutting the middle line of the falling-mould, determine the places of the joints E, D, and F, upon the falling-mould. Produce the line G E to I, and through the point D draw the line D I parallel to the line G H. Divide the line D I into two parts, according to the directions given in Art. 47, Part II, and from the point of division J let fall a perpendicular J L, cutting the middle line of the falling-mould in L. From the point L draw L K parallel to D I or G H, and cutting the line E I in K; the points E, I, and K, are the relative heights of the middle line of the falling-mould at E, L, and D.

METHOD OF FINDING THE DIRECTION OF THE ORDINATES FOR THE CONSTRUCTION OF THE FACE-MOULDS.

7. Let A F B, fig. 1, plate 1, be a quadrant of the plan of the wreath, similar to A B, fig. 4, and let the middle line

A F B be drawn upon it. Join the points A and B, and upon the opposite sides of A B erect the perpendiculars A C and B D. Make the length of A C equal to the height E K of the falling-mould, fig. 4, and B D equal to the height K I, and join the points C and D, cutting the line A B in E. Upon the middle line A F B of the plan set off the point F, according to the division J of the line D I of the falling-mould, and through the points E and F draw the line E F ; E F is the direction of the ordinates of the plan of the wreath, as proved in Art. 6, Part II.

THE ORTHOGONAL FACE-MOULD.

8. Draw the quadrant of the plan A B, fig. 3, plate 1. Draw ordinates A C, B D, &c., from the middle line of the plan parallel to the common section E F of fig. 1. Draw the line C E at right angles across the ordinates at any convenient distance from the plan A B, and make E D equal in length to the sum of the heights E K I of the falling-mould. Upon the hypotenuse C D erect the ordinates C L, D J, &c., each perpendicular to the line C D. Make the length of these ordinates equal to the length of the ordinates E B, A C, &c., drawn to the middle line A B of the plan. A curve drawn through the points J I L thus found, is the middle line of the orthogonal face-mould.

9. The method of finding the breadth of the orthogonal face-mould has been explained in Art. 28, Part II. In the present example, the shaded figure drawn upon the line B D is a section of the square wreath, of the exact size that the hand-rail is intended to be. The dotted square that is constructed upon the hypotenuse C D produced, and which contains within it the shaded section of the square wreath, is of the same size that a section of the orthogonal solid would be, which would contain within its surfaces the square wreath. The dots drawn upon the line C D at D, are the middle points of the common and orthogonal face-moulds ; their use in the

application of the common face-mould to the orthogonal solid is explained in Art. 30, Part II.

THE COMMON FACE-MOULD.

10. Let A B, fig. 2, Plate 1, be similar to the plan A B, fig. 1, and draw ordinates A C, B D, F H, and G K, parallel to the line E F of fig. 1. At any convenient distance from the plan A B, draw C E at right angles across the ordinates, and from the point C draw C D, making the angle C D E equal to the angle C D E of fig. 3. From the points where the ordinates B D, A C, &c., cut the line C D, draw ordinates C L, D J, &c., at right angles to C D. Make the length of these ordinates equal to that of their corresponding ordinates upon the base D J to E B, C L to A C, &c., and through the points thus found trace curves, these curves are the outlines of the common face-mould.

If the triangles denoted by the letters C E D, of figures 2 and 3, are made to revolve upon their bases C E, until they stand perpendicularly upon the planes A C B E, the hypotenuses C D will lie vertically over the lines C E ; and if the face-moulds J L, and the ordinates in connection with them, are then made to turn over, they will lie above the plan and ordinates A B, A C, and B E. In which case the hypotenuse C D will be parallel to the major diameter of the cylindrical section ; and if a parallel to the hypotenuse were drawn through N, the point of intersection of the radii N I and N J, this line would coincide with the major diameter of the above section.

CONSTRUCTION OF THE BUTT-JOINT LINES OF THE FACE-MOULDS.

11. In the construction of the butt-joint lines of a hand-rail by the principles explained in Part II, the plan of the joint is drawn upon the plan of the wreath, as at A, B, and C, fig. 4, plate 1. The angle that the plane of the butt-joint makes with a perpendicular line is determined by the aid

of the falling-mould, as at E, D, and F, fig. 4, plate 1. The given angle E A B, in diagram, Art. 14, Part II, is the angle, found as above, by the help of the falling-mould.

In those cases where both quadrants of the plan of the stairs are similar to each other, the upper and lower parts of the falling-mould are alike, and the face-mould is the same for both quadrants of the wreath, requiring merely to be reversed. In which case, the plane of the butt-joint makes right angles with the hypotenuse D B of the triangle D A B, diagram, Art. 14, Part II; and, consequently, the joint-lines across the face-mould are obtained, as shown in diagram, Art. 21, Part II, by drawing them at right angles to the produced radii of the cylindrical section, which is the particular case referred to in Art. 19, Part II.

The formation of the butt-joint is, in the above case, extremely simple; the dihedral angle of the joint, or the angle which the plane of the butt-joint makes with the surface of the plank is a right angle, consequently the application of a joiner's square, after the joint-lines of the face-mould are obtained, is all that is necessary in making the joint.

12. In diagrams 2 and 3, plate 1, are shown the methods of drawing the joint-lines across both ends of the face-mould. In fig. 3, these lines are drawn through ordinates traced from the middle line of the plan at A and B to the points J and L of the middle line of the orthogonal face-mould; and, in fig. 2, the joint-lines are drawn through the middle of the ends of the common face-mould. The lines J N and I N are the radii of the cylindrical section traced from the radii B F, G F, of the plan; the point N corresponding with the centre of the quadrant F. The radius I N is produced to H, and J N to K, and the joint-lines J H and K L are drawn at right angles to them.

In the common form of hand-rails, the part I L of the face-mould is generally straight, corresponding with the straight part A G of the plan. Where this occurs, a common square applied to the edge of the face-mould, gives the joint-line near enough for all practical purposes.

13. In the present and following examples, the difference between the middle of the common and orthogonal face-moulds at the vertex of the cylindrical section, is marked upon the hypotenuse by the points at O or D. The distance between these points is employed, as shown in Art. 40, Part II, in the application of the common face-mould to the orthogonal solid, for the purpose of bringing the solid into the cylindrical form.

CONSTRUCTION OF THE MOULDS OF A WREATH FOR A HALE-SPACE CONNECTING STRAIGHT FLIGHTS.

14. In the following example, fig. 1, plate 2, A B C is the plan and E F G the falling-mould of a wreath. The steps J and K of the straight flights, and the half-space H I, are constructed to the development of the dotted middle line of the plan A B C; and the falling-mould is drawn to the nosing-line of this development. The plans of the joints of the wreath are at A, B, and C; and the place of the middle joint upon the falling-mould is determined by producing the plan-line B of the middle joint to the point 3 of the falling-mould. The places E and G of the other joints A and C are determined upon the falling-mould by making the distances B L and B M equal to the development of the dotted middle line of the plan from B to A and from B to C, and then erecting the perpendiculars L E and M G, cutting the middle line of the falling-mould in E and G. The lines E, F, and G, drawn at right angles across the falling-mould give the direction of the joints.

15. In the present, as in the last example, both quadrants of the plan of the stairs are alike, therefore the upper and lower parts of the falling-mould are similar to each other, and one face-mould reversed serves for both quadrants of the wreath.

16. The diagram for obtaining the relative heights 1 2 and 2 3 of the falling-mould is constructed to the under side

of the falling-mould in this example, but its similarity to the diagram in fig. 4, plate 1, drawn for the same purpose, may be observed by referring to that figure. The object of drawing the diagram differently in the present example from that of fig. 4, plate 1, is merely to show a different application to the same purpose of the same principles.

The distance 1, 2, is the difference of the heights of the points 6 and 5 of the middle line of the falling-mould; and the distance 2, 3, is the difference of the heights of the points 5 and 3 of the above line.

17. Make the quadrant A B, fig. 2, plate 2, similar to the plan A B, fig. 1, plate 2, and join the points A and B as in the example, Art. 7, Part III. Make the length of the perpendicular A C equal to 1 2, fig. 1; make the length of B D equal to 2 3 of fig. 1, and join the points C and D. From the point where the line C D cuts the line A B draw E F to a point F, determined as directed in Art. 42, Part II; E F is the direction of the horizontal ordinates required in tracing out the face-moulds.

18. Fig. 3, plate 2, shows the orthogonal face-mould constructed in the same manner as directed for the orthogonal face-mould in Art. 8, Part III. The ordinates A C, B D, &c., are drawn parallel to the common section E F, fig. 2, the line E C is drawn at right angles to the ordinates, and the hypotenuse C D is drawn through the point D, E D being made equal to the sum of the heights 1, 2, 3, of the falling-mould. Fig. 4 is the common face-mould constructed in the same manner as directed for the common face-mould in Art. 8, Part III, the hypotenuse C D, fig. 4, being drawn parallel to the hypotenuse C D, fig. 3.

The butt-joint lines of the above face-moulds are obtained in the same manner as directed for the joint-lines of the face-moulds in plate 1.

CONSTRUCTION OF THE MOULDS FOR A WREATH OVER WINDERS.

19. A B C, fig. 1, plate 3, is the plan of a wreath over winders, similar to the winders of the plan, fig. 2, Part I, and E D F is the falling-mould, constructed to the development of the middle line of the plan.

The places of the joints upon the falling-mould are found in a manner similar to those of plates 1 and 2, and the relative heights of the different parts of the falling-mould are determined at E, K, and I, by the same process as that explained in Art. 6, Part III.

20. The direction of the ordinates of the cylindrical section is obtained by constructing fig. 2, as directed for fig. 1, plate 1:—Make A C, fig. 2, plate 3, equal in length to E K, of fig. 1, and make B D, fig. 2, equal to K I, of fig. 1. Through the points C and D draw the line C D cutting A B in E, and make the distance A F, measured upon the middle line A B of the plan, fig. 2, equal to J I of the falling-mould. Through the points E and F draw the line E F; this line gives the direction of the ordinates of the plan of the wreath as in the former examples.

21. In fig. 3, A B is the plan of a quadrant of the wreath; the ordinates B D, A C, &c., are drawn parallel to the line E F of fig. 2, and the hypotenuse C D is drawn through the point D, E D being made equal to the sum of the heights E K I of the falling-mould. The line C E, of fig. 3, is drawn as directed for the same line in former examples, at any convenient distance from the plan A B and at right angles to the ordinates; and the orthogonal face-mould J I L is constructed as in former examples.

22. Both quadrants of the plan of the stairs A B C, fig. 1, are alike, consequently, both parts of the falling-mould E D and F D are alike, and face-moulds, therefore, for one quadrant only of the wreath are necessary. The joint-lines

J H and L K, drawn at right angles to the produced radii of the cylindrical section, as in the preceding examples, will be the joint-lines of the wreath.

The common face-mould in the above example is not given, but the instructions given for the construction of the common face-moulds in the previous examples will enable the student to construct it without further explanation.

CONSTRUCTION OF THE MOULDS FOR ONE QUARTER OF WINDERS AND A QUARTER-SPACE.

THE FALLING-MOULD.

23. In fig. 5, plate 4, A B C is the plan of the wreath, A B the winders, S the quarter-space, and A and C flyers adjoining them.

The development of the middle line of the plan of the wreath is drawn at G R H, and the development of the steps and of the nosing-line are shown at T U V.

In this example, the two quadrants of the plan, and consequently of the falling-moulds, differ considerably from each other; and, therefore, separate face-moulds will be required for each quadrant of the wreath. The middle line of the falling-mould is drawn parallel to the developed nosing-line T U V, and is merely eased off at the angles.

The places of the joints upon the falling-mould are determined, as in the previous examples, by the perpendiculars G E, R D, and H F, cutting the middle line of the falling-mould at the points E, D, and F; and the directions of the joints are determined by the lines E, D, and F, drawn at right angles across the falling-mould.

24. As separate face-moulds are required in this example for each quadrant of the wreath it will be necessary to determine the relative heights of both the upper and the lower parts of the falling-mould. These heights are determined by diagrams similar to those employed in the examples already given, the construction of which are as follows:—

Through the middle point D of the falling-mould draw the line I M parallel to G H, and cutting the perpendiculars erected upon G and H at the points I and M. Through the points J and L determined, as directed in Article 47, Part II, draw the perpendiculars J P and L Q. From the points P and Q, where these lines cut the middle line of the falling-mould, draw the parallels P K and Q N. The points E, K, and I, are the relative heights of the lower half of the falling-mould; and the points M, N, and O, are the relative heights of the upper half.

THE ORTHOGONAL FACE-MOULD.

25. In the example before us the construction of the orthogonal face-moulds only are given; these face-moulds are given to both the upper and lower quadrants of the wreath.

Fig. 2 shows the face-mould of the lower quadrant of the wreath answering to the part E D of the falling-mould; and fig. 4, shows the face-mould of the upper quadrant.

In these examples the middle line only of the plan of the wreath is drawn, being all that is necessary in the construction of the orthogonal face-mould. If the common face-mould were constructed the outlines of the plan would of course be required.

In fig. 1, A F B is the middle line of the plan, corresponding with A B, fig. 5, the points A and B are joined by the straight line A B, and A C and B D are drawn at right angles to A B. A C is made equal in length to E K of fig. 5, and B D to K I, and the points C and D are joined by the straight line C D. The distance A F of fig. 1, is made equal to the distance I J, fig. 5, and the line of horizontal ordinates E F is drawn, giving the direction of the ordinates B D and A C, of fig. 2. The line C E, of fig. 2, is drawn at right angles to these ordinates, and the line C D is drawn through the point D, E D being made equal to the sum of the heights E K I of the falling-mould. In fig. 3, we have the line A C made equal to N O of fig. 5, and the line B D to M N, the straight part A F of the plan corresponding with Q F of the falling-mould. The ordinates A C and B D of

fig. 4 are, as in the preceding examples, drawn parallel to the line E F, fig. 3, and E D is made equal to the sum of the two heights M N and N O. The shaded section of the square wreath and the dotted rectangle, showing the size of the section of the orthogonal solid, are drawn at O, figs. 2 and 4; and the middle points of the common and orthogonal face-moulds are dotted upon the lines C D at O, in the above figures.

THE BUTT-JOINT LINES.

26. In the preceding examples, plates 1, 2, and 3, the construction of the joint-lines of the face-mould have required the employment of a particular case only of the general problem, described in Art. 14, Part II. The present example requires the application of the above-mentioned problem in its general form.

In Art. 17, Part II, the method of finding the plan of the intersection of the planes C D B and C A E of the tetrahedron, diagram 19, is shown. In applying this to the construction of the butt-joint lines of a hand-rail, the plane C D B must be taken for the surface of the plank out of which the wreath is cut, and the plane E A C for the plane of the butt-joint. The common section E C of the plane of the butt-joint and the surface of the plank will be the joint-line upon the face-mould; and the plan of this section, which is F C, will be the plan of the joint-line upon the plan of the wreath.

In fig. 1, plate 5, I L C is the plan of a wreath, with the diagram I C J H K drawn upon it, for the purpose of determining the common section G H, Art. 10, Part II. The line C B, drawn through the middle joint of the plan, is made equal in length to C K, as shown by the circular arc K B, and C G is drawn at right angles to C B, meeting the common section G H in G, and forming the base of the right angled triangle G C B.

In fig. 2, plate 5, E D F is part of a falling-mould, and D B the direction of the middle joint-line drawn across it, making the angle A C B with the perpendicular A C drawn through the middle of the plan of the wreath; the angle A C B is the given angle referred to in the problem, Art. 14, Part I.

In fig. 1, plate 5, draw D C parallel to the common section G H, and from the point D draw D A parallel to G C. From the point A draw A E, making the angle B A E equal to the angle A C B of fig. 2. From the point E draw E F parallel to A B, and join the points F and C. The line F C is the plan of the butt-joint line, which line traced with ordinates from the plan of the wreath, is the butt-joint line across the face-mould.

Figs. 1 and 3, plate 4, show the construction of the butt-joint lines for the face-moulds J L of figs. 2 and 4. The lines B M are the joint-lines upon the plan, and the lines J N are the joint-lines, traced with the ordinates M N, upon the face-moulds.

Fig. 2, plate 5, shows the construction of the joint-lines on a larger scale, and their relation to the angle A C B formed by the perpendicular A C and the joint-line B D of the falling-mould.

27. In referring to fig. 1, plate 5, it will be seen that the diagram C D B A is similar to the diagram C D B A of Art. 17, Part II, hence the application of the above to the construction of the butt-joint lines.

The joint-lines of the end L of the orthogonal face-moulds, figs. 2 and 4, plate 4, are not constructed as directed above; the same general problem serves, however, for the construction of the joint-lines of either end of the face-mould. But in cases where a part of the plan of the wreath is straight, as stated in Art. 12, Part III, the joint-lines may be drawn at right angles across the straight end of the face-mould, or they may be drawn at right angles to the produced radii of the cylindrical section, as in the examples, plates 1, 2, and 3.

Before leaving the subject of the joint-lines, it may be remarked, that if the triangles G C B and H K C, fig. 1, plate 5, are made to revolve upon their bases G C and H C, until their sides C B and C K become perpendicular to the plane G C H, their points B and K will coincide, and the lines G B, G H, and H K, will form a triangle, the plane of which will coincide with the surface of the plank.

WINDERS CONNECTING A LANDING AND A STRAIGHT FLIGHT.

28. Fig. 1, plate 6, is an example of winders connecting a landing and a straight flight. It is a plan which is by no means recommended, but as it occurs, it is thought advisable to give the construction of the face-moulds for it. The middle line only of the falling-mould is drawn, being all that is in any case necessary in the construction of the face-moulds of a wreath. The places and directions of the joints are marked upon the falling-mould, and the relative heights of the falling-mould are found by diagrams as in previous examples. The positions of the diagrams drawn upon the falling-mould are varied in this example from that of plate 4, the relative heights of the different parts of the falling-mould are all given upon the middle line B A.

29. The line G H, of fig. 2, is the common section or the direction of the ordinates of the lower quadrant of the wreath, and the angle B A E, made equal to B A E of the falling-mould, gives the joint-line F C.

30. In fig. 4, plate 6, is shown the construction of the common face-mould of the lower quadrant of the wreath, in which the ordinates are drawn parallel to the common section G H, fig. 2, and the joint-line F C is drawn parallel to the joint-line F C of fig. 2. Fig. 6, is the orthogonal face-mould of the same quadrant, constructed as directed for this mould in former examples.

The small triangle B upon the plan of the wreath, fig. 4, is what is cut off from the plan by the plan of the joint-lines, and the small triangle A is what is added to it in the construction of the joint-lines of the plan. The triangles, traced to the face-mould, are shown at A and B, and the lines A B are what were given in the old methods of hand-railing as the joint-lines of the face-mould. It will be seen how erroneous they were. It is indeed a matter of surprise that hand-

rails could have been constructed upon such erroneous principles, since the face-moulds were in all cases considerably too short; workmen in their first attempts, almost invariably experienced a failure, and only remedied the defects of the system by making random allowances where painful experience taught.

31. Figs. 3, 5, and 7, plate 6, are the geometrical lines for the face-moulds of the upper quadrant of the wreath: they are constructed in every respect in the same manner as figs. 2, 4, and 6, of the same plate.

THE FACE-MOULD AND FALLING-MOULD OF A WREATH OVER AN ELLIPTICAL PLAN.

32. As the last complete example of the construction of the face-mould that will be given an elliptical plan is selected, principally for the purpose of giving the construction of the butt-joint lines in accordance with the general problem, to both ends of the wreath.

A B C, fig. 1, plate 7, is the middle line of the plan of the wreath: this plan is equally divided for winders; and A B C, fig. 2, is the development of the line A B C, fig. 1. The development of the steps is drawn upon the line A B C, and the falling-mould is drawn parallel to the nosing-line of this development. The relative heights, 1, 2, 3, of the first quadrant A B of the wreath are determined upon the perpendicular 1 3, of fig. 2, as in the previous examples. The curve 1 4 6, fig. 3, is the plan of the first quadrant of the wreath, and the lines 1 2, and 6 3, are drawn at right angles to the chord 1 6. The line 1 2 is made equal in length to 1 2 of the falling-mould, the line 6 3 of fig. 3 to 2 3 of the falling-mould, and the points 2 and 3 are joined by the line 2 3 cutting the chord 1 6 in the point 5. The curve 1 4 6 is divided into two parts at the point 4, and the line 4 5 is drawn; this line is the common section described in Art. 10, Part II, and is consequently the direction of the ordinates 1 C, 6 D, &c.

The orthogonal face-mould E F is traced from these ordinates in the usual manner, and the breadth of it is obtained by drawing a section of the square wreath upon the line 6 D, and inclosing it with the dotted rectangle drawn upon the hypotenuse C D, as directed in the previous examples.

The face-moulds of one quadrant of the plan will, in this example, answer for the whole of the wreath, as all the quadrants A B, B C, &c., are alike; and for the same reason the joint-lines are drawn at right-angles to the produced radii of the cylindrical section, J E to J F and I F to I E, the radius E H being produced to I, and the radius F H to J.

33. Fig. 4, plate 7, shows the plans of the joint-lines of both ends of the face-mould constructed, on the principles explained in Art. 26, Part III, to the plan A D B of one quadrant of the wreath, the common section C D being found in the same manner as the common section 4 5, of fig. 3. If the quadrants of the plan vary from each other, the common section, or the direction of the ordinates, must be found for each quadrant of the wreath separately.

In the present example the construction of the common face-mould is not given, but a reference to former examples will explain the method of constructing it: the plan of the wreath, and not the middle line, must of course be laid down in the construction of the common face-mould.

GENERAL REMARKS.

34. The foregoing illustrations of the construction of the face-moulds of a hand-rail it is presumed will be sufficient to conduct the student through the most difficult cases that can occur. In carefully examining them, it will be seen that the same general principles are employed throughout. If, therefore, a thorough knowledge of these principles is obtained, no difficulty will be experienced in adapting and applying them in every possible case. The method of obtaining the heights of the different points of the falling-mould, and the construc-

tion of the diagram for finding the common section, shown at Art. 10, Part II, are reduced to their simplest form. The construction of the cylindrical section from the common section referred to, avoiding the complexity of employing oblique ordinates, by drawing a base at right angles across the ordinates of the plan, and by this means constructing the section of the cylinder from ordinates drawn at right angles to the hypotenuse, leave nothing to be desired as regards simplicity. The construction of the butt-joint lines, according to the particular case demonstrated in Arts. 19 and 20, of Part II, is perfectly geometrical, no method can be more simple or more easily applied.

35. The construction of the dihedral angle and of the butt-joint lines, according to the general problem in those cases, where the two quadrants of the wreath vary in form from each other are given, that nothing may be wanted, and that no uncertainty may exist. But if in those cases the length of the face-mould is obtained, as in example, Art. 36, page 41, where the joint-lines across the face-mould are drawn through the ordinates E and F, the joint may be formed upon the bench, as will be explained, by an easy and a correct method, independently of the geometrical method given by the general problem.

APPLICATION OF THE COMMON FACE-MOULD TO THE PLANK.

36. In cases where the use of the common face-mould is preferred for cutting the wreath out of the plank the hypotenuse, from which the ordinates of the section are traced, or the line E F, fig. 31, page 41, must be laid parallel to the square edge of the plank; and the bevel C K D, being marked upon the edge, will give the position of the face-mould on both sides of the plank. If the common face-mould, thus applied, does not lie in the required position, a temporary edge may be formed to the plank, the angle C K D being marked upon it; and the line E F being laid parallel to it, as if it were the

edge of the plank, the position of the face-mould will thus be determined on any part of the plank that we may choose. The application of the orthogonal face-mould, as before stated, Art. 28, Part II, is simple enough, and requires no explanation.

APPLICATION OF THE FACE-MOULD TO THE ORTHOGONAL SOLID.

37. Two methods of bringing the orthogonal solid into the cylindrical form have been noticed in Arts. 30 and 31, Part II. The first of these needs no elucidation; but of the second, as several geometrical lines are employed, one complete example on an enlarged scale will be given.

EXAMPLE. In plate 8, A B and E F are the plans of one quadrant of a wreath; in fig. 1 the orthogonal face-mould is shown at C D, and in fig. 2 the common face-mould is shown at G H. The joint-lines of these face-moulds are drawn at right angles to the produced radii of the cylindrical section, and the lines C D and G H are drawn parallel to the hypotenuse, at equal distances from the centres 3 and J of the quadrants. The ordinate 3, of fig. 1, and its corresponding ordinate I J, of fig. 2, are drawn through the centres 3 and J of the quadrants; these lines are made use of in applying the common face-mould to the plank, in the manner described in the last Article. Their use in the orthogonal system are to determine the position of the common face-mould upon the two opposite sides of the orthogonal solid.

38. Fig. 3 is the orthogonal face-mould, constructed at fig. 1; and fig. 4 is the common face-mould, constructed at fig. 2. The lines A B, drawn upon these face-moulds, are similar to the lines C D and G H, drawn upon the face-moulds at figs. 1 and 2. Fig. 5 is the orthogonal solid, cut out by the orthogonal face-mould, fig. 3, with the line A B drawn upon it similar to the line A B upon the face-mould, fig. 3. The lines 1 1, drawn across the face-moulds 3 and 4, are in the same position as the ordinates J and 3, drawn across the face-moulds in figs. 1 and 2; and the line 1, drawn

at right angles across the edge of the solid, fig. 5, is the same line transferred from the orthogonal face-mould to the solid. The object of drawing these lines is, as before stated, to determine the position of the common face-mould when applied to the orthogonal solid. Figs. 6 and 7 exhibit the orthogonal solid with the common face-mould applied to both its upper and lower sides.

39. Before we can apply the common face-mould as above exhibited, we must find the distance between the middle of the common and orthogonal face-moulds, at the vertex of the cylindrical section, or, in other words, the distance that the common face-mould must be moved upwards or downwards upon the orthogonal solid to produce the requisite cylindrical form. The method of finding this distance is given in Art. 40, Part II, and the distance is exhibited in fig. 1, plate 8, at the points 1 2 ; the point 1 being the middle of the common, and the point 2, the middle of the orthogonal face-mould. In figs. 6 and 7, the lines 2 2, drawn across the edge of the solid, are the same as the line 1 of fig. 5, they are transferred from the ordinate drawn across the orthogonal face-mould.

40. In figs. 6 and 7 set off the distance 1 2, equal to the distance 1 2 of fig. 1, and set off the distance 2 3 in the same manner : these distances should be set off upon the flat side of the orthogonal solid and not upon the curved edge, or a trifling error will in consequence occur. The oblique lines drawn upon the edge of the solid to the lines 1 and 3 give the pitch of the plank ; these lines would be vertical if the solid were placed in its proper position over the plan. The points 1 and 2 of fig. 1 vary in distance from each other with the thickness of the plank, receding from, or approaching towards each other, as the plank employed is increased or decreased in thickness ; if the plank were without thickness, the points would then coincide with each other. Hence the necessity of setting off the exact thickness of the plank that is to be employed, before proceeding to determine the distance of these points.

The lines A B, drawn upon the face-mould, and also upon both sides of the solid, determine the places of the face-mould upon the solid, as shown in figs. 6 and 7, where, on one side of the solid, the line drawn across the face-mould is brought to the line 1, and on the other side of the solid it is brought to the line 3, the line A B of the face-mould coinciding with the line A B of the solid in both positions of the face-mould.

41. In those cases where the face-mould overhangs the solid, the form of the face-mould cannot, of course, be marked upon the solid, but as the mark invariably falls upon the solid on one side, at the point where on the opposite side the face-mould overhangs the solid, we can always determine the cylindrical form by fixing the face-mould upon the solid where the marks do not occur. The face-mould may be fixed upon the solid in the bench vice, or by any other means, and when thus fixed, the superfluous parts of the solid may be worked off.

The plane, termed a round, is employed on the concave side of the solid, and the solid is formed with the round worked parallel to the oblique line drawn upon the edge of the solid. The convex side of the solid is formed in a similar manner, being worked to the face-mould on one side, and to the mark of the face-mould upon the other. The convex, as well as the concave side, must be worked in straight lines parallel to the oblique line upon the edge of the solid.

FORMATION OF THE BUTT-JOINT.

42. The solid being worked into the cylindrical form, according to one of the processes above explained, we have the vertical sides of the wreath formed. But before proceeding to square the wreath from these vertical sides, it will be necessary to bring the joints of the wreath into something like their proper form. The joint-lines of the face-mould are marked upon the flat surfaces of the plank, and these surfaces, and consequently the joint-lines upon them, would be destroyed in the process of squaring the wreath, hence the necessity of jointing the wreath before the above process is completed.

In those examples where the upper and lower quadrants

of the wreath are alike, let the end of the solid be cut to the joint-line of the face-mould, and let it be worked to a square, applied to the flat surface of the plank. The corresponding ends of the solids being brought together, thus prepared, and the vertical sides of the solids being made to coincide, we have the parts forming the wreath in their proper position with regard to each other. The middle points of the ends of the two solids should be made to coincide exactly with each other, as both the common and orthogonal face-moulds are constructed to the middle of the wreath.

43. When it occurs that the upper and lower quadrants of the wreath vary in form from each other, a process differing slightly from the above must be adopted in forming the joint. The face-moulds are, as above stated, constructed to the middle of the wreath, and not to the surface of the plank; if, therefore, the solids forming the wreath, were cut off square to the joint-lines drawn upon the surface of the plank, when the dihedral angles of the joint are not right angles, the wreath would, in all probability, be too short, or the plane of the joint would not be in its proper position. The solids must therefore be cut somewhat longer than the joint-lines drawn upon the surface of the plank denote, to make allowance for the oblique dihedral angles formed by the planes of the butt-joint and the surface of the plank; the face-mould giving the length of the solid, in the above case, in the middle point only of the wreath. The allowance of length needs not in any case to be large, for the dihedral angles above-mentioned never vary to any extent from right angles.

In finding the dihedral angles by the method given in Art. 18, Part II, it must be borne in mind that the angles of the upper and lower quadrants of the wreath are not alike, a separate process must therefore be gone through for each quadrant. But, as stated in Art. 35, Part III, the dihedral angles need not to be constructed in the formation of the joint; they involve a problem of some difficulty, and require great care and precision in the construction of them, and, after all, a single stroke of the jointing-plane might destroy

all that geometrical accuracy which so much pains had been taken to preserve.

FORMATION OF THE WREATH.

44. After the cylindrical solid is produced, and the ends of it are cut to the joint-lines of the face-mould, proceed to square the wreath as directed in page 44 : or the wreath may be formed with practice at once from the cylindrical solid, without going through the process of squaring ; a section of the moulded wreath being marked upon the middle of each end of the cylindrical solid, the vertical sides of the solid giving the positions of the section. But to those who are not in the habit of constructing hand-rails, the safest method to be pursued is to properly square the wreath, and then to mark the moulded section upon the ends of it thus squared. When the solid is squared, draw lines parallel to its arrises : the arrises being worked off, the wreath may be moulded according to the moulded section marked upon the ends of the solid.

DETERMINATION OF THE SIZE OF THE LEAST SOLID THAT WILL CONTAIN THE WREATH.

45. In determining the size of the least solid that will contain the wreath, it is necessary to show that the angle A D E, fig. 27, Part 2, or the angle formed by a base drawn at right angles across the ordinates, the perpendicular A D, and the hypotenuse E D, is less than any other angle that can be formed by an hypotenuse, the same perpendicular and any other base drawn across the ordinates.

46. Proposition. The shortest line that can be drawn from any given point to a given line, is that which is drawn at right angles to the given line from the given point.

Let A C, fig. 36, be a straight line, and B a point at any distance from it ; A B drawn from the given point B to the line A C, and at right angles to A C, is the shortest line that can be drawn from the point B to the line A C.

Let B C be drawn obliquely to the line A C, the lines A C, A B, and B C form together a triangle right-angled at A. By the thirty-second proposition, Book I, Euclid, the three angles of a triangle are together equal to two right angles, and, by construction the angle at A is a right angle, the angle at C is therefore less than a right angle, and by Euclid, proposition the 18th, Book I, the greater side of a triangle is opposite to the greater angle, therefore, the side B C is greater than the side B A, being opposite to the angle A, which is greater than either of the other angles B or C. By the above means it can be proved that every other line drawn from B to the line A C is greater than the line B A which is drawn at right angles to the line A C.

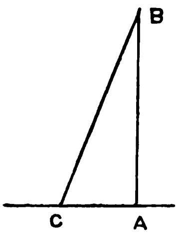


FIG. 36.

47. PROPOSITION. Let C D be a straight line, C A a line drawn at right angles to C D, and A D a line drawn obliquely to C D. Let A B be a line drawn at right angles to the plane A C D, and let C B and D B be joined; the angle C B A is less than the angle D B A.

By Art. 46, the shortest line that can be drawn from a point to a line is that which is drawn at right angles to the given line. The line A C is drawn from the point A to the line C D, and at right angles to C D, it is, therefore, shorter than A D, which is drawn obliquely from the point A to the line C D. By Euclid, prop. 21, Book I, the greater angle is subtended by the greater side, consequently the less angle is subtended by the less side, and it is shown that the side A C is less than the side A D, therefore, the angle C B A is less than the angle D B A. In the same manner

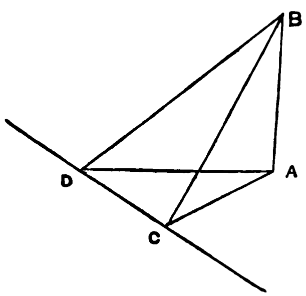


FIG. 37.

it may be proved, that the angle C B A is less than any other angle that can be formed at B by any other line drawn from B to C D.

48. From the two last propositions it will be seen that the angle at D, fig. 16, page 27, is less than any other angle formed by the perpendicular B D, and an hypotenuse drawn to any other base than B C. The angle at D, fig. 16, or fig. 27, is the angle that the surface of the plank makes with a perpendicular at the vertex of the cylindrical section. This is the point of greatest difference between the winding surface of the wreath and the surface of the plank out of which it is cut. If, therefore, the oblique section of the plank will, at this point, contain a section of the wreath, we may with certainty conclude that every other section of the plank will amply contain it.

From the above reasons the angle at the vertex of the cylindrical section has been chosen as the point for determining the sections of the oblique and orthogonal solids, as shown in fig. 27, and in all the examples given in the plates.

49. The surface of the wreath and the surface of the plank are parallel to each other at the point where the ordinates cross the curve of the face-mould at right angles. Consequently, this is the point of least difference between the positions of the two surfaces, a less thickness of plank, would, therefore, be required here than at any other point.

JOINING THE WREATH UPON THE BENCH.

50. In Art. 42, Part III, is given a method of joining the parts of the wreath, when the upper and lower quadrants are both alike. But when the parts differ from each other, the above method cannot be applied, and even when it is applied, the slightest inaccuracy in joining the parts is capable of throwing the wreath considerably out of its place. So that some check is necessary by which we can ascertain whether the parts of the wreath when joined together pass through the

proper heights, or whether they vary from the form intended to be produced. In referring to any of the falling-moulds, in the examples given in the plates, it will be recollected that the points through which the quadrants of the wreath pass are determined by the falling-moulds, and the distances of these points from each other are, in consequence, determined at the same time. Now three of these points are situated in the middle points of the joints of the wreath, and consequently, if the joints are accurately preserved, as given by the face-moulds, we can always refer to them in putting the parts of the wreath together. In plate 9, figs. 1 and 2 exhibit the upper and lower quadrants of a wreath, squared and ready to be joined together. The parts D E and F G, fig. 4, are the two quadrants of the wreath, brought into their proper positions, preparatory to being put together. Fig. 3, shows the same parts joined, the rod A B giving the distance between the points A and B.

51. In plate 9, E F, fig. 5, is a drawing-board, upon which is shown a squared wreath put together. The part D of the wreath lies upon the drawing-board, and the part A C is raised above the board by the blocks B B, which blocks are made equal in height to the part D of the wreath added to the diameter of the well-hole. It will be observed, that by this arrangement the parts of the wreath, if properly put together, will lie evenly upon both the drawing-board and the blocks; the rod A D determining the distance at which the points A and D of the wreath must be kept from each other. So that if the lengths of the parts of the wreath are obtained we can fit them together, and determine whether they are in their true position or not by applying the rod, and observing the manner in which they lie upon the drawing-board and blocks.

THE JOINTING ROD.

52. The method of determining the length of the rod A B of fig. 3, or A D, fig. 5, plate 9, is as follows: Let A B fig. 2, plate 10, be part of a falling-mould with the joint-lines

of the wreath drawn across it, the line A being the joint-line of the lower end, as at A, fig. 3, plate 9, and the line B, the joint-line of the upper end of the wreath, as at B, fig. 3, plate 9. Through the middle of the line A, draw the horizontal line A D, and from the middle of the line B, let fall the perpendicular B D; the line B D is the difference of the perpendicular heights of the middle points of the two joints A and B. But in applying the rod A B, fig. 3, plate 9, to the wreath, when the wreath is joined, it will be seen that it is brought to touch the concave sides of the wreath at the points A and B, the rod lies, therefore, obliquely across the well-hole. Upon the line A D, let a plan of the wreath be drawn as D C, fig. 2, plate 10, and from the point C, the diameter of the well-hole, draw the oblique line C E. The line C E is the length of the rod to be employed. The length of the rod, which may be termed the jointing-rod, can be determined in every case where a falling-mould is constructed. For example, in fig. 4, plate 1, the difference of the heights of the middle points of the joints E and F, gives the perpendicular distance of the points from each other, and by constructing a diagram similar to that shown in fig. 2, plate 10, the length of the rod may be ascertained. Having determined the length of the rod, there can be no difficulty in applying it in the process of joining the wreath. The planes of the joints ought to be made at right angles to the curves of the wreath, and the hand-rail screws should, when inserted, be perpendicular to these planes, or the parts of the joints may be displaced in tightening the screws.

THE SCROLL.

53. Fig. 1, plate 10, shows a scroll with part of the straight rail joined to it; the part A is kept in an horizontal position, and the part B is brought into the rake of the pitch-board P. In the scrolls that are constructed over winders, the rake of the pitch-board cannot always be applied as it is shown in fig. 1, the hand-rail in such cases following the steps in the same manner as a wreath.

THE MITRE-CAP.

54. The terminations of hand-rails are sometimes effected by what is termed a mitre-cap. The mitre-cap is a circular block of wood of greater diameter than the breadth of the hand-rail, turned to a form that will make a proper intersection with any oblique section of the hand-rail that may be determined upon. In fig. 3, plate 10, the shaded part 1 2 is a transverse section of an oval rail described from the centres 1, 2, 3, 4 ; the flat part, or underside of the hand-rail at 1, is formed by cutting off the oval at the point A, where the curve is cut by the perpendiculars drawn through the centres 3 and 4. The large circle L H K is the outline of the mitre-cap, a section of which through the centre is required of that form which will intersect with the hand-rail cut to any given mitre.

Let the given mitre at which the hand-rail is to be inserted in the mitre-cap be L E C. Draw the line 2 1 E, through the centre M of the mitre-cap, and through the middle of the section of the hand-rail. Find the mitre section, or the form of the section of the hand-rail upon the mitre-line E C, by drawing the ordinates 1 2, A B, &c., prolonging them to the mitre-line E C, erecting the ordinates C D and E F, and drawing the curve F D C ; the length of the ordinates C D and E F being made equal to their corresponding ordinates A B and 1 2.

The section of the mitre-cap is traced from the mitre-section in the following manner :—Draw the semi-diameter M G of the mitre-cap at right angles to the line M 2 ; from the centre M describe the arcs E I and C G, and upon the points I and G erect the perpendiculars I K and G H. Make I K equal in length to E F, and G H equal to C D, and trace the curve G H K and continue it to the line 2 M. M G H K is the section of the mitre-cap that will form a proper intersection with the given mitre of the hand-rail.

The hand-rail may be cut to the mitre, and the mitre-section may be marked upon C E by laying the rail, cut as

above directed, upon the line C E, and drawing the line F D C by it without the necessity of tracing out the section.

The mitre-cap may be of any convenient diameter, not less than the breadth of the hand-rail, and the hand-rail may be of any form most suitable for taste and convenience.

VENEERED HAND-RAILS.

The veneered hand-rail is sometimes employed, in which case the core of the hand-rail is formed of deal, and the veneer of the straight parts of the rail is made pliable by being subjected to the action of steam in a closed tank. While the veneer is hot, it is withdrawn by degrees from the tank, and is wrapped and tied upon a piece of wood of the same shape as the core of the hand-rail, and after drying it, it is glued upon the core.

The core of the wreath is constructed upon the same principles as the wreath of any other hand-rail, and may be got out by the orthogonal system. The form of the hand-rail being entirely dependent upon the form of the core, it is necessary to bestow as much care upon the formation of the core as upon the formation of a hand-rail that is not to undergo the process of veneering.

The veneering of the wreath is accomplished by cutting the veneer into shreds about three-sixteenths of an inch broad, with a cutting-gage, and gluing five or six at a time upon the core of the wreath. They are placed upon the core side by side, in the same order as they are cut from the veneer, commencing at one end of the wreath, and glueing and tying them on with a cord as the work proceeds. A chisel driven into the core serves to bring them together in the process of tying them on. When they are sufficiently dry, five or six more are put upon the core in the same manner, and so on until the whole is covered. In putting the veneers upon the wreath steam is brought to play upon them by a nozel attached to a pipe with a universal joint.

The joining of the veneers of the wreath with the veneers of the straight part of the hand-rail is accomplished after the hand-rail is fixed in its place. The veneers of the wreath are

left loose for three or four inches from the end of the core, and they are also left longer than the core in order to overlap the joining of the cores of the wreath and the straight part of the hand-rail. After the hand-rail is fixed, the narrow slips are cut from one edge only to a point, and they are then let into the veneer of the straight part, forming what is termed a dog-toothed or forked-joint. When the whole of the veneers are thus prepared, they are glued and tied down in their places, the joinings of the veneer being well rubbed with the hammer, or any other convenient instrument, for the purpose of uniting the grains of the wood and closing the joinings. The scroll of the veneered hand-rail is constructed of the same materials as the veneer; it is not veneered except at that part termed the shank, which may or may not be veneered as most convenient. The forked joint is employed in uniting the veneer and the scroll in the same manner as is described for joining the veneers of the wreath and of the straight part of the hand-rail. The carved scroll is well adapted for the veneered hand-rail, as the joining of the veneer may be neatly accomplished at the junction of the plain and carved parts of the scroll, or beneath the foliage of the carved work.

Any of the fancy woods may be employed in the veneered wreath, but the darker coloured seem more fit for the purpose than any other. Rosewood or mahogany, for instance, when the veneering is well executed, show but little of the joinings of the veneer. The hand-rail in such cases appears as if constructed of one entire piece, and has a very beautiful effect. Oak, so ill adapted for the wreathed hand-rail, on account of the parts where the grain of the wood is crossed having so different an appearance from the rest, may be most advantageously employed in veneers, where no such objection can arise.

The apparatus employed in the veneering process need not to be of an expensive nature; any vessel in which steam can be generated in sufficient quantities serves the purpose. The pipe leading from the steam generator should be clothed, so as to prevent as much as possible the radiation of heat, as heat is the essential requisite in the process.

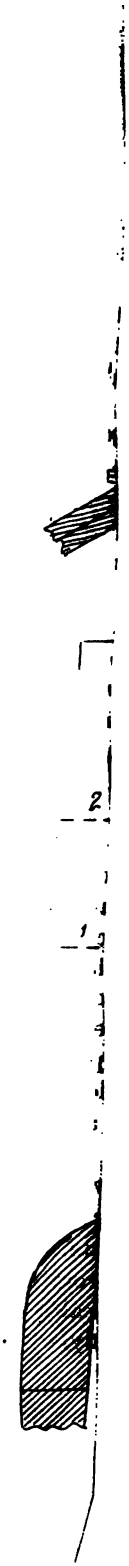
FORMS OF HAND-RAILS.

Hand-rails are made of various forms, depending upon the taste of the designer or the work with which they are intended to correspond; for instance, in gothic work, hand-rails partaking of some gothic form are commonly employed. In common practice the o-gee, or the oval form, is commonly used. The oval form is perhaps more easily constructed than any other, the moulding of the wreath requiring but little greater skill than the moulding of the straight parts of the hand-rail, in consequence of which this form is extensively employed. The method of describing the oval rail is shown in fig. 3, plate 10.

It would be useless, however, to attempt to lay down rules for giving the forms of hand-rails, the two grand objects to be attained are ornament and adaptation to the purpose, neither of which must be sacrificed for the attainment of the other.

THE END.

T. C. Johns, Wine Office Court, Fleet Street.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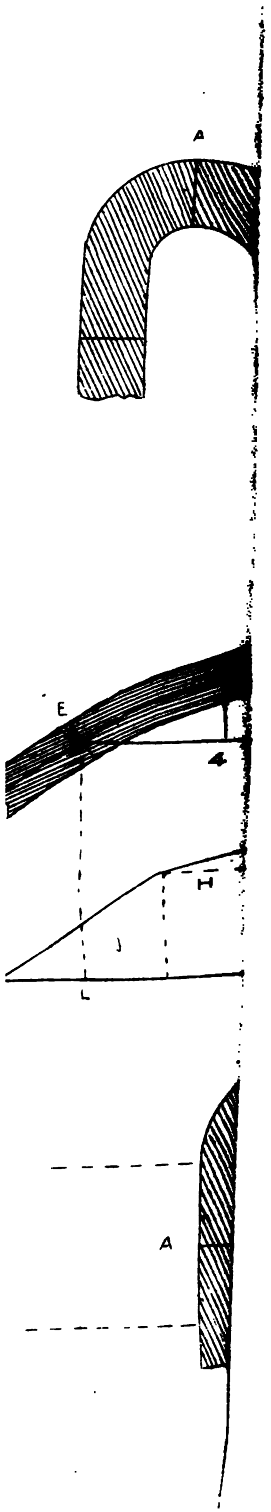
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